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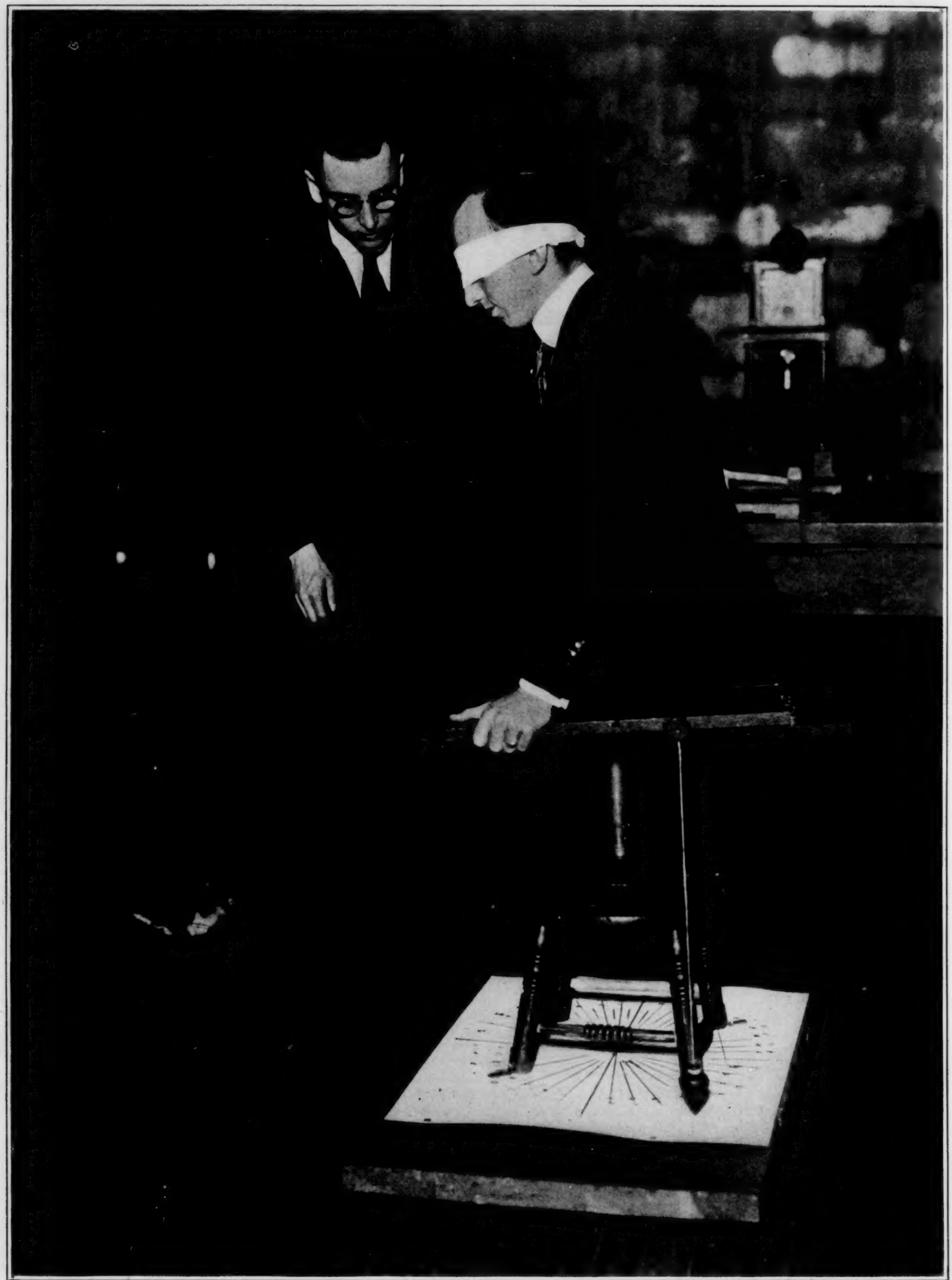

PSYCHOLOGICAL EXAMINATIONS—THE ORIENTATION TEST FOR AVIATORS, THE SUBJECT IS REVOLVED AND TRIES TO TELL AT WHAT POINT HE STOPS (SEE PAGE 205)

SCIENTIFIC AMERICAN MONTHLY

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A NATIONAL SURVEY OF WASTE

WHEN the plan was first suggested of forming a great national federation of professional engineers, there were critics a-plenty, who, despite the aid rendered to the Government by organized engineering during the war, could see no great benefit either to the public or the engineers themselves from such a federation.

The federation has only just been formed, but it is already beginning to function and has mapped out a program of service in many directions. However, one special service has been initiated which must dispel any lingering doubts as to the enormous value to the nation of this huge organization. At the convention in Syracuse last month, Herbert Hoover, President of the Federation, announced the appointment of a committee on elimination of waste in industry. This committee is to study the whole nation, as if it were a single industrial organism, in order to discover economic weaknesses; in other words, it is to make a "great national assay of waste." The task that has been set before this committee is a stupendous one and most intricate in its ramifications, but with the coöperation of between one hundred thousand and two hundred thousand professional engineers enrolled in the Federation it can be carried to a successful conclusion.

A preliminary survey has already been made of the principal elements that contribute to production waste, and lines of action have been mapped out.

The outstanding problem at the present moment is unemployment. Three million idle men are walking the streets today. The situation is a serious, but not a permanent one. We knew from past experience that these men will eventually find employment again and we shall rise on the crest of another wave of prosperity. But why should we have such waves? Why should there be periods of industrial depression? In some lines of work periods of unemployment are of annual or seasonal frequency. The most glaring example is the coal industry. Because of the habit of producing only upon demand and closing down the mines during slack periods instead of laying up stores for future demands, miners find themselves out of work thirty per cent of the time; in other words, thirty per cent more men are employed than are needed to carry on this class of work if it were distributed uniformly throughout the year. It will not be the aim of the committee to reduce employment, but rather to distribute labor to better advantage. There is no thought of appointing an individual or establishing a commission which may autocratically order men from one field of industry to another, but so to stabilize the industries asto retard if not eliminate fluctuations in production, and this calls for nation-wide coöperation.

Abnormal conditions usually spell waste. Prosperity does not necessarily indicate efficiency—quite the contrary. When the demand for products exceeds the supply of men capable of producing them the output per man usually falls far below the normal. When factory wheels are humming and working overtime incompetent men and misfits are employed, under the urge of necessity, and immediately there is a reaction upon the competent and skilled men, resulting in a lowering of the quality if not of the quantity of their product, in the wake of which there is unrest, a large labor turnover, and labor conflicts, all of which represent serious wastes. On the other hand when demands for labor fall off the efficiency of those individuals who remain at work mounts higher, but the efficiency of labor as a class falls off because of the large proportion of men without employment and the net result to the nation is a loss.

The object of the committee is not to limit but to regulate or direct production. As Mr. Hoover put it "If we could attune the whole industrial machine to the highest pitch, agriculture as well as manufacture, an increase in production would mean a directly increasing standard of living. When ten men or one hundred million men divide their united output, they can by doubling their output have twice the amount to divide. The problem of doubling the output is to direct it to commodities or services that they can use. There is no limit to the increase of living standards, except limitations of human strain, scientific discovery, mechanical invention and natural resources."

It is very evident that we are not utilizing our industrial resources to their fullest extent. In the year 1918 we produced twenty per cent more commodities than we are producing today, despite the fact that twenty per cent of our manpower was withdrawn for service in the army. It is estimated that we could produce thirty or forty per cent more if all our forces were properly synchronized.

Labor problems are by no means the only ones that will occupy the attention of the committee. Wastes of all kinds will be sought out wherever they may be found. The aim will be not merely to discover and classify these wastes but to offer suggestive criticism looking toward a remedy of unfavorable conditions, to the end that the whole nation may employ its entire resources to the very best advantage.

DIAMETER OF BETELGEUSE

A NOTE received from Prof. George E. Hale of Mt. Wilson Observatory gives the angular diameter of Alpha Orionis as 0."046 instead of 0."045 as stated on page 104 of our February issue. This measurement was made by Mr. Pease of the Mt. Wilson Observatory staff. If the parallax of the star is 0."018, which is a measure that some astronomers believe to be more nearly correct than the figure 0."015, the linear diameter of the star works out to about 240 million miles.

The Quest of the Absolute

An Essay on Modern Developments in Theoretical Physics

By "Aurelius" (Dr. Francis D. Murnaghan, Baltimore)

It was a foregone conclusion that among the essays submitted in competition for the Einstein prize there would be a good number of the highest order of scientific merit, which would nevertheless be eliminated from final consideration by their failure to measure up—or perhaps we should say, measure down—to the standard of intelligibility of the general reader, as this standard was interpreted by the Judges. If the question had been put to us thus baldly in advance, we should doubtless have conceded the possibility that among the essays thus adjudged to be over the head of the audience to which they were supposed to be directed, there would be one standing out above its fellows quite as unmistakably as the winning essay could ever hope to stand out among those that really hit the mark of simplicity and freedom from technical matter.

Whether this was to be anticipated or not, it represents what happened. The Judges and the Einstein Editor have no hesitation in pronouncing the essay of Dr. Murnaghan, presented herewith, to be, for the man who is equipped to read it with full understanding, altogether the most illuminating of the essays submitted in the contest, if not indeed the most successful discussion of comparable length that has appeared anywhere. The Judges were agreed that Dr. Murnaghan's essay was of doubtful value before a general audience, and that in the presence of an essay such as Mr. Bolton's appeared to be it could not properly claim the prize; but it is so very good of its kind that they clung to the last moment to the possibility of its being the best, and only allowed it to be eliminated from their consideration after the most searching examination of Mr. Bolton's work had shown that it was all it seemed to be.

This criticism of Dr. Murnaghan's work makes it plain that it demands publication, and equally plain that the place for it is here, rather than in the Scientific American *proper. By all means it deserves the distinction of being the first of the competing essays to appear in the* Scientific American Monthly, *and we hasten to give it this distinction.*—Editor.

We shall discuss the more important aspects of the theory popularly known as the "Einstein Theory of Gravitation" and shall try to show clearly that this theory is a natural outcome of ideas long held by physicists in general. These ideas are:

(a) The impossibility of "action at a distance;" in other words we find an instinctive repugnance to admit that one body can affect another, remote from it, instantaneously and without the existence of an intervening medium.

(b) The independence of natural, *i.e.*, physical, laws of their mathematical mode of expression. Thus when an equation is written down as the expression of a physical law it must be satisfied, no matter what units we choose in order to measure the quantities occurring in the equation. As our physics teacher used to say "the expression of the law must have in every term *the same dimensions*." More than this the choice of the quantities used to express the law—if there be a choice open—must have no effect on its correctness. As we were told—"all physical laws are capable of expression as relations between vectors or else as relations between magnitudes of the same dimensions." We shall hope to make this clearer in its proper place in the essay, as its obvious generalization is Einstein's cardinal principle of relativity.

The measurements which an experimental physicist makes are always the expression of a coincidence of two points in space at the same time. If we ask such an experimenter what he means by a *point in space* he tells us that, for him, the term has no meaning until he has a material body with reference to which he can locate the point by measurements; in general it requires *three* measurements and he expresses this by saying that space has *three* dimensions. He measures his distance, as a rule, parallel to three mutually perpendicular lines fixed in the material body—a Cartesian reference-frame so-called. So that a "point in space" is equivalent to a given material reference-frame and three numbers or *coordinates*. If, for any reason, we prefer to use a new material reference-frame the coordinates or measurements will change and, if we know the relative positions of the two material reference-frames, there is a definite relation between the two sets of three coordinates which is termed a transformation of coordinates. But which particular material reference-frame shall we use? The first choice would, we think, be that attached to the earth. But, even yet, we are in doubt as there are numberless Cartesian frameworks attached to the earth (as to any material body) and it is here that our idea (b) begins to function. We say it must be immaterial which of these Cartesian frames we use. In each frame a *vector* has three components and when we change from one frame to another the components change in such a way that if two vectors have their three components equal in one framework they will be equal in any other attached to the *same* material system. So our idea (b), which says that our physical equations must be vector equations, is equivalent to saying that the choice of the framework attached to any given material body can have no effect on the mode of expression of a natural law.

Shall we carry over our idea (b) to answer the next question: "To which material body shall we attach our framework?" To this question Newton gave one answer and Einstein another. We shall first consider Newton's position and then we may hope to see clearly where the new theory diverges from the *classical* or *Newtonian* mechanics. Newton's answer was that there is a particular material frame with reference to which the laws of mechanics have a remarkably simple form commonly known as "Newton's laws of motion" and so it is preferable to use this framework which is called an *absolute* frame.

What is the essential peculiarity of an absolute frame? Newton was essentially an empiricist of Bacon's school and he observed the following facts. Let us suppose we have a framework of reference attached to the *earth*. Then a small particle of matter under the gravitational influence of surrounding bodies, including the earth, takes on a certain acceleration A_1. Now suppose the surrounding bodies removed (since we cannot remove the earth we shall have to view the experiment as an abstraction), and another set introduced; the particle, being again at its original position, will begin to move with an acceleration A_2. If both sets of surrounding bodies are present simultaneously the particle begins to move with an acceleration which is *approximately but not quite* the sum of A_1 and A_2. Newton postulated that there is a certain absolute reference frame in which the approximation would be an equality; and so the acceleration, relative to the material frame, furnishes a convenient measures of the effect of the surrounding bodies—which effect we call their *gravitational force.* Notice

that if the effect of the surrounding bodies is small the acceleration is small and so we obtain as a limiting case, *Newton's law of inertia* which says that a body subject to no forces has no acceleration; a law which, as Poincaré justly observed, can never be subjected to experimental justification. The natural questions then arise: which is the absolute and privileged reference-frame and how must the simple laws be modified when we use a frame more convenient for us—one attached to the earth let us say? The absolute frame is one attached to the fixed stars; and to the absolute or "real" force defined as above, we must add certain terms, usually called centrifugal forces. These are referred to as *fictitious* forces because, as it is explained, they are due to the motion of the reference-frame with respect to the absolute frame and in no way depend on the distribution of the surrounding bodies. Gravitational force and centrifugal forces have in common the remarkable property that they depend in no way on the material of the attracted body nor on its chemical state; they act on all matter and are in this way different from other forces met with in nature, such as magnetic or electric forces. Further Newton found that he could predict the facts of observation accurately on the hypothesis that two small particles of matter attracted each other, in the direction of the line joining them, with a force varying inversely as the square of the distance between them. This law is an "action at a distance" law and so is opposed to the idea (a).

We have tacitly supposed that the space in which we make our measurements is that made familiar to us by the study of Euclid's elements. The characteristic property of this space is that stated by the theorem of Pythagoras that the distance between two points is found by extracting the square root of the sum of the squares of the differences of the Cartesian coordinates of the two points. Mathematicians have long recognized the possibility of other types of space and Einstein has followed their lead. He *abandons the empiricist method* and when asked what he means by a point in space replies that to him a point in space is equivalent to four numbers *how obtained it is unnecessary to know a priori;* in certain special cases they may be the three Cartesian coordinates of the experimenter (measured with reference to a definite material framework) together with the time. Accordingly he says his *space is of four dimensions.* Between any two "points" we may insert a sequence of sets of four numbers, varying continuously from the first set to the second, thus forming what we call a curve joining the two points. Now we define the "length" of this curve in a manner which involves all the points on it and stipulate that this length has a physical reality, *i.e.*, according to our idea (b) its value is independent of the particular choice of coordinates we make in describing the space. Among all the joining curves there will be one with the property of having the smallest length; this is called a *geodesic* and corresponds to the straight line in Euclidean space. We must now, for lack of an *a priori* description of the actual significance of our coordinates, extend the idea of vector so that we may speak of the components of a vector no matter what our coordinates may actually signify. In this way are introduced what are known as *tensors;* if two tensors are equal, *i.e.*, have all their components equal, in any one set of coordinates they are equal in any other and the fundamental demand of the new physics is that *all physical equations which are not merely the expression of equality of magnitudes must state the equality of tensors.* In this way no one system of coordinates is privileged above any other and the laws of physics are expressed in a form independent of the actual coordinates chosen; they are written, as we may say, in an absolute form.

THE GRAVITATIONAL HYPOTHESIS

Einstein flatly denies Newton's hypothesis that there is an absolute system (and, indeed, many others before him had found it difficult to admit that so insignificant a part of the universe as our fixed star system should have such a privileged position as that accorded to it in the Newtonian Mechanics). In any system, he says, we have no reason to distinguish between the so-called *real* gravitational force and the so-called *fictitious* centrifugal forces—if we wish so to express it gravitational force is fictitious force.[1] A particle moving in the neighborhood of material bodies moves according to a law of inertia—a physical law expressible, therefore, in a manner quite independent of the choice of coordinates. The law of inertia is *that a particle left to itself moves along the geodesics or shortest lines in the space.* If the particle is remote from other bodies the space has the Euclidean character and we have Newton's law of inertia; otherwise the particle is in a space of a non-Euclidean character (the space being always the four-dimensional space) and the path of the particle is along a geodesic in that space. Einstein, in order to make the theory more concrete, makes a certain stipulation as to the nature of the gravitational space which stipulation is expressed, as are all physical laws, by means of a tenso equation—and this is sometimes called his law of gravitation.

Perhaps it will be well, in exemplification, to explain why light rays, which pass close to the sun, should be bent according to the new theory. It is *assumed* that light rays travel along certain geodesics known as minimal geodesics. The sun has an intense gravitational field near it—or, as we now say, the departure of the four-dimensional space from the Euclidean is very marked for points near the sun—but for points so remote as the earth this departure is so small as to be negligible. Hence the form of the geodesics near the sun is different from that near the earth. *If the space surrounding the sun were Euclidean the actual paths of the light rays* would appear different from geodesics or straight-lines. Hence Einstein speaks of the curvature of the light rays due to the gravitational field of the sun; but we must not be misled by a phrase. Light always travels along geodesics (or straight lines—the only definition we have of a *straight-line* is that it is a geodesic); but, owing to the "distortion" of the space they traverse, due to the sun, these geodesics reach us with a direction different from that they would have if they did not pass through the markedly non-Euclidean space near the sun.

The consideration of the fundamental four-dimensional space as being non-Euclidean where matter is present gives a possibility of an answer to the world old question: Is space finite or infinite?: Is time eternal or finite? The fascinating possibility arises that the space may be like the two-dimensional surface of a sphere which to a limited experience seems infinite in extent and flat or Euclidean in character. A new Columbus now asks us to consider other possibilities in which we should have a finite universe—finite not only as to space measurement but as to time (for the space may be such that all of the four coordinates of its points are bounded in magnitude). However, although Einstein speaks of the possibility of a finite universe, we do not, personally, think his argument convincing. Points on a sphere may be located by the Cartesian coordinates of their stereographic projections on the equatorial plane and these coordinates, which might well be those actually measured, are not bounded.

THE SPECIAL RELATIVITY THEORY

In our account of the Einstein theory we have not followed its historical order of development for two reasons. Firstly, the earlier Special Relativity Theory properly belongs to a school of thought diametrically opposed to that furnishing the "General Theory of Relativity" and, secondly, the latter cannot be obtained from the former by the process of generalization as commonly understood. Einstein, when proposing the earlier theory, adopted the position of the empiricist so that to him the phrase, *a point in space*, had no meaning without a material framework of reference in which to measure space

[1]Not all gravitational fields may be transformed away by a proper choice of coördinates. If this were so, the space, whose nature is independent of any choice of coördinates, would always be Euclidean.

distances. When he came to investigate what is meant by time and when he asked the question "what is meant by the statement that two remote events are simultaneous?" it became evident that some mode of communication between the two places is necessary; the mode adopted was that by means of light-signals. The fundamental hypothesis was then made that the velocity of such signals is independent of the velocity of their source (some hypothesis is necessary if we wish to compare the time associated with events, when one material reference-system is used, and the corresponding time when another in motion relative to the first is adopted). It develops that time and space measurements are inextricably interwoven; there is no such thing as *the* length of a body or *the* duration of an event but rather these are *relative* to the reference-system.[2] Minkowski introduced the idea of the space of events—of four dimensions—but this space was supposed Euclidean like the three-dimensional space of his predecessors. To Einstein belongs the credit of taking from this representation a purely formal mathematical character and of insisting that the "real" space—whose distances have a physical significance—is the four-dimensional space. But we cannot insist too strongly on the fact that in the gravitational space of the general theory there is no postulate of the constancy of velocity of a light signal and accordingly no method of assigning a time to events corresponding to that adopted in the special theory. In this latter theory attention was confined to material systems moving with uniform velocity with respect to each other and it developed that the velocity of light was the ultimate velocity faster than which no system could move—a result surprising and *a priori* rather repugnant. It is merely a consequence of our mode of comparing times of events; if some other method—thought transference, let us say—were possible the velocity of this would be the "limiting velocity."

In conclusion we should remark that the postulated equivalence of "gravitational" and "centrifugal" forces demands that anything possessed of inertia will be acted upon by a gravitational field and this leads to a possible identification of matter and *energy*. Further our guiding idea (a) will prompt us to say, following the example of Faraday in his electrical researches, that the geodestics of a gravitational space have a physical existence as distinct from a mere mathematical one. The four-dimensional space we may call the *ether*, and so restore this bearer of physical forces[3] to the position it lost when, as a three-dimensional idea in the Special Relativity Theory, it had to bear an identical relation to a multitude of relatively moving material systems. The reason for our seemingly paradoxical title for an essay on Relativity will be clear when it is remembered that in the new theory we consider those space-time properties which are *absolute* or devoid of reference to any particular material reference-frame. Nevertheless, although the general characteristics of the theory are thus described, without reference to experiment, when the theory is to be tested it is necessary to state what the four coordinates discussed actually are—how they are determined by measurement. It is our opinion that much remains to be done to place this portion of the subject on a satisfactory basis. For example, in the derivation of the nature of the gravitational space, surrounding a single attracting body, most of the accounts use Cartesian coordinates as *if the space were Euclidean* and step from these to polar coordinates by the formulæ familiar in Euclidean geometry. (Newton's law of gravitation is found to be a first approximation and a higher order of approximation explains the famous irregularity in the motion of the planet Mercury). But these details are, perhaps, like matters of elegance, if we shall be allowed to give Einstein's quotation from Boltzmann, to be left to the "tailor and the cobbler."

[2]Thus when it is said that a body contracts or that a clock runs slow when it is put in motion no actual physical change is implied. The judgment of different observers—one at rest with respect to the body and one not—are different.

[3]Necessary to avoid an "action at a distance" theory.

BUILDING A WALL AROUND THE NORTH POLE

IN a recent lecture delivered at the well-known Norwegian city, Bergen, Prof. M. Bjerknes made the startling proposal that a wall should be built around the North Pole in the effort to protect mankind from the effects of the bitter cold waves and icy storms, which sweep southward from that region. This proposition, of course, must not be taken too literally, but rather as an effective image of speech. As reported in *Prometheus* (Berlin), No. 42, 1920, and reproduced in the *Naturwissenschaftliche Umschau*, the Supplement of the *Chemiker Zeitung* (Berlin) for September, 1920, Professor Bjerknes is of opinion that it would be of the greatest advantage for the weather service of all the countries in the Northern Hemisphere to establish a ring of meteorological stations around the North Pole, for the purpose of giving warning of probable polar storms. He declares that the majority of the accidents at sea which have taken place during recent years can be ascribed to the lack of information in advance concerning those dangerous storms occasioned by cold currents of the arctic atmosphere. In such cases forewarned would be forearmed, since it is believed that the information received from such meteorological stations would readily enable meteorologists to foretell the weather for a full week in advance, thus making it possible to advise captains of ships running between Europe and America as to the best ocean paths to follow in order to be sure of good weather throughout the entire journey. It is estimated by the author of this suggestion that from 300 to 500 stations in a circuit about the North Pole would be required to furnish a sufficient amount of data, and the immediate expenditure for establishing these is estimated at 10,000,000 kr. The plan, undoubtedly, has much in its favor and the proposed expenditure seems comparatively small in view of the benefits that would undoubtedly result from it.

THE ORIGIN OF DUNES AND THE BALANCE OF NATURE

A GERMAN geologist, Mr. W. Behrmann, recently published in the Journal of the Berlin Geological Society, *Zeitschrift d. Gesellschaft f. Erdkunde* (Berlin) No. 3-4, 1919, a theory of the origin of dunes which is not only interesting in itself, but which suggests far-reaching conclusions as to the equilibrium of natural forces, and the methods by which this balance is from time to time disturbed. He believes that the dunes may well have originated in the track left by an animal. Such a track, slight as the impression made in the sand may be, occasions a slight deviation of the wind. Thus there is produced a scarcely perceptible sand wave which begins to increase in size until it results in a huge dune. After a longer or shorter period the growth of the dune comes to an end, just as a sand bar formed by a river is eventually destroyed by the river itself. Behrmann states his theory that there is a constant effort in the nature which surrounds us to produce an equilibrium of forces. But this equilibrium is disturbed by any sort of action, such, for example, as the track made by the animal in the sand; in this instance, for example, the velocity of the wind is lessened at certain places by the aforesaid track. From this first disturbance there follows a second which is stronger in action and reaction. The growth of the dune continues until its very increase in size finally reaches a point where it acts as an opposing force. If the dune rises above the stratum of air where wind blows and sand is borne then the sand bank can no longer maintain itself against the increased force of the waters it dams up, so that a state of equilibrium is produced. The formula thus stated in readily comprehensible terms applies not only to the sand dune, but to the increase of strength in various other natural forces, which very augmentation leads finally to a condition of equilibrium. It will be seen that this principle is capable of wide extension throughout nature.—Translated from an abstract in the *Naturwissenschaftliche Umschau* of the *Chemiker Zeitung* for June, 1920.

FIG. 1. A HUNTER FROM THE CUEVA DEL MAS D'EN JOSEP—½ NATURAL SIZE

FIG. 2. ARCHER FROM THE ROCK FRIEZE OF ALPERA—½ NATURAL SIZE

FIG. 3. RUNNERS FROM THE CUEVA DE LOS CABALLOS—½ NATURAL SIZE

Artists of the Glacial Period*

Prehistoric Rock Paintings Recently Discovered in Eastern Spain

By Prof. Hugo Obermair

THE cave paintings which have been discovered during the last two decades in no inconsiderable quantities in western Europe and which indisputably date from the glacial period, undoubtedly belong to the most surprising of all the discoveries made in the realm of the history of primeval days. The reader is probably familiar with the remarkable works of art found in Comabrelles, Font-de-Gaume, Laussel, and Marsoulas in southern France, to which must be added those in northern Spain (especially in the Provinces of Santander, Asturias), including the celebrated caves of Altamira, Castillo, Pasiega and Pindal. From all these caverns there have been obtained a number of paintings, or carvings on rock, most notable among which are the large and extremely realistic pictures of animals, including the mammoth, the wild horse, the bison, the reindeer, the mountain goat, the cave lion, etc.; to these must be added some singular half-animal caricatures and certain still unexplained "symbolic" characters. Among the above pictures, which are painted by means of charcoal and red and yellow ocher, scenic groupings are never found, and naturalistic looking representations of human beings are also entirely lacking.

It is now no longer doubted among experts in the matter that these productions of art, which are in many cases of very admirable quality, were the creation of the diluvial period, and, likewise, of the time of the disappearance of the glacial period (Vide H. Obermaier, *der Mensch der Vorzeit*) (Man in Prehistoric Times, Berlin, 1912, Chapter V, pp. 223-258). It is further evident that this art originally fell within the domain of the religious ideas connected with the chase and with the world of spirits, on which account we are apt to find in each of the great zones only a few painted caves, which were probably held to be "sacred" and served as altars of culture.

In contrast to these works of art found in the Aquitania-Cantabria zone, which have been quite well known for a number of years, is another art zone confined exclusively to the eastern half of Spain, extending from the provinces of Lérida and Teruel to the provinces of Jaén and Almeria. This *Levantine art*, as it may be called, has been revealed only very recently, in large part during the war, during which period I had the privilege of lending some considerable assistance in the affair.

Only a few large caverns are found in eastern Spain, and these are buried as in the northern part of the peninsula in the deep recesses of the mountains; on the other hand there is a plentiful supply of shallow, rocky cavities or niches over which a protecting roof of rock frequently projects. As a typical example I may mention here the *Cueva de los Caballos* or *Cave of Horses* which is 9 meters long, 3 meters deep, and about the same height on an average. This cave is difficult of access, being situated in the upper third of the deeply cleft and precipitous slope (about 100 meters in height) of the Valltorta Gorge, which lies not far from Albocàcer in the province of Castellon. In this same locality are found also the *Cueva del Civil* and the *Cueva Salvadora*, which are destined to rouse an international interest (H. Obermaier v. P Wermert *Las Pinturas Rupestres* (Rock Paintings) *del Barranco de Valltoria*, Castellon, Madrid, 1919). The illustrations which accompany this article are reproduced from the pages of this monograph.

Among these Levantine images carvings are found but seldom, while paintings, executed usually with light or dark red pigments, are much more plentiful. Since these are exposed to the more or less direct rays of the hot sun of this climate, they are usually a good deal faded or else obscured by an incrustation of dust. It is only necessary, however, to moisten them carefully with a sponge to see them in many cases revived in all their freshness. This application of the sponge does not injure the pictures, since the pigments which were probably rubbed up originally with grease, have formed in the course of centuries a chemical union with the surface of the rock, so that they may be said to have actually become "fossilized." Doubtless, of course, time and the hand of man have either wholly or partially destroyed many others.

The figures observed in this zone of eastern Spain are quite as realistic as those in the northern zone of Cantabria, but are in general much smaller. Many pictures of animals are found including deer, mountain goats, wild cattle, wild horses, and wild boars, as occasionally also the wild ass, the elks and the chamois.

The peculiar interest of this group of pictures, however, resides in the fact that it contains ***numerous representations***

*Translated for the *Scientific American Monthly* from *Die Umschau* (Frankfurt a.M.) for January 1, 1921.

of the human form done in a most realistic manner, in contrast to the northern zone where, as we have said, such pictures are entirely lacking and which were evidently carefully abstained from.

These "portraits" of human beings are usually full of life and motion. Female figures very seldom appear among them, and when they are seen they are clad in long bell-shaped skirts; the male figures are always naked, but usually carry weapons and wear certain ornaments as shown in Fig. 1. Among these are seen very wonderful caps and "crowns" as well as armlets and knee bands, while attached to the shoulders or hips are fluttering ribbon-like decorative strips of material. Very conspicuous in these pictures are the bows and arrows with which hunters or warriors are armed; there are usually a number of extra arrows in evidence by way of a reserve supply, and now and then a regular quiver is provided for these as indicated in Fig. 2. The figures are portrayed in the greatest variety of attitudes and often with a daring which is truly amazing and rather takes one aback.

While in some of the pictures great regard is paid to correct proportions of the human body and to the realistic representation of the more important details, in others this fidelity to nature is more or less sacrificed in favor of picturesqueness of movement, or in order to give a special emphasis to certain physical characteristics. Thus we often see

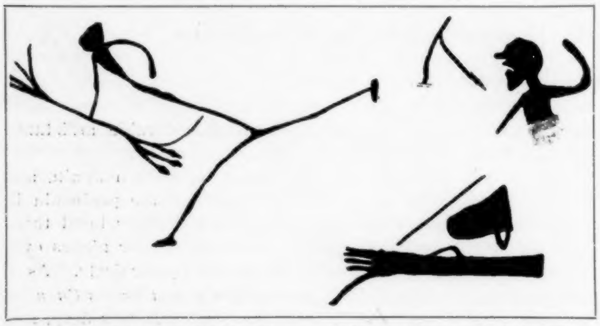


FIG. 4. HUNTER DONE IN RED, FROM THE CULVA DE LOS CABALLOS—ABOUT ⅓ NATURAL SIZE

FIGS. 5 AND 6. FROM THE CUEVA SATTADORA. *ABOVE*, FIGURE IN RED; *BELOW*, A QUIVER AND COOKING UTENSIL

types which are actually "caricatures," with an excessive length of the body, with an extremely broad chest, or with the most daring narrowing of the hips, as well as on the other hand figures with excessively fat legs as shown in Fig. 3. In the same way there are "hunters" whose figures are reduced almost to merely linear dimensions and yet almost seem all the more to fairly live and breathe as in Fig. 4.

Faithfulness of portraiture is not sought for and the pictures are, therefore, to be regarded as "non-individual," since there is always found an omission of details of the head. In those few exceptions where details of the face are reproduced they are not conclusive, so that it is not possible to form from them any definite idea as to the peculiarities of the race which produced them.

These pictures of human beings consist partly of single figures and partly of groups of men or of men and animals, and in such cases they form true pictorial compositions. Thus we possess vivid scenes of deer hunting from the *Cueva de los Caballos* and the *Cueva del Mas d'en Josep* (the Barnyard of Joseph), both situated in the Valltortas Gorge, a superb wild boar baiting from the *Cueva del Charco del Agua Amarga* (the Cave of the Pool of Bitter Water) in the province of Teruel, camp scenes from the last mentioned rocky grotto as well as from Alpera in the province of Albacete; a group of dancing women from Cogul in the province of Lérida; an original trail finder from Morella la Vella in the province of Castellon and many others.

Now and then one comes across really charming "genre" pictures of which we reproduce the example shown in Fig. 6. This represents a quiver which is furnished with a handle and from which extend four arrows and a bow, together with a basket possibly made of skins, and a slender rod or staff.

H. Breuil, P. Wernert, and other experts upon rock pictures, as well as myself are convinced that this naturalistic Levantine art of Spain, is a contemporary equivalent of the Cantabrian zone of art mentioned in the beginning of this article, and that it belongs, like the latter, to the end of the glacial period. Evidence of this is to be found in the many and indisputable similarities of style and technique between the animal pictures in both zones, among which are found certain ones which in the east, as well as in the west, are solely diluvial, such as the wild ass and the elk. A minute study of the character of the weapons and of the ornaments of these naked figures of huntsmen leads to the same conclusion, as does, also, the fact that the naturalistic rock art of the Iberian Peninsula had in general disappeared at about the beginning of the present geological era (*i.e.*, at about 12 to 15 thousand years B.C.), "giving way to an art" purely diagrammatic and geometrical in character (*Vide* my work *El Hombre Fosil* [Fossil Man], Madrid, 1916, Chapter X.).

As respects the psychological background of this art of eastern Spain we are of the belief that it is mainly connected with ideas of magic, either in the form of protective magic or else of enemy magic or the magic of the chase. It seems probable that it was because of such a connection of ideas that the artist carefully refrained from making individual likenesses or "portraits" from the fear that these might be employed as means of evil by crafty practicers of "black magic."

However this may be, these most recent discoveries give us, at any rate, valuable information as to our remotest ancestors, information concerning their forms of art and their personal adornments, their habits and their occupations, such as only a few years ago the boldest fancy dared not hope to obtain.

WHAT KIND OF GOODS DYES BEST?

THE following information which is of importance to cleaners and dyers as well as to those who may carry on such operations in their own homes is taken from the January issue of *Dye Stuffs:*

"Goods containing yellow, such as brown, tan or orange, should be dyed dark brown, dark green, plum or black. They do not dye good blue.

"Blue, gray, and taupe should be dyed dark blue, red, burgundy, plum, green or black. Faded gray or taupe does not cover well in darker shade of same color and should be made one of the above colors, or a dark brown. Blue will not dye brown, nor brown blue.

"Corduroys do not, as a rule, make nice black, but do make nice colors. Checked garments should never be dyed black, but can be made dark green, green or brown.

"Hard woven goods that are faded do not cover well in any color but black. Soft materials, such as velours, when not too badly faded, can be covered in one of the darker shades.

"Made over garments that have contained plaits, if faded, must always be dyed black. White serges that are sunburned can only be dyed black.

"Buttons, buckles and fancy trimmings should be removed. It is also advisable to let out hems of sleeves and skirts to provide for shrinkage, which sometimes occurs.

"No dyer can keep goods from shrinking, if they are inclined to do so, no matter how careful he is in dyeing.

"Following are a few points concerning the plaiting of skirts:

"Plaiting takes up something like 2-3; for instance, 3 yards of goods plaited will be one yard wide.

"The average skirt has from 3 to 3½ yards.

"Goods to be plaited should be put in 'sheet-like form' so it can be placed in the plaiter, hemmed or faced at bottom, sewed together except at one seam, say at vent or placket.

"Plaited goods can be cleaned any number of times without replaiting."

The Bridge as a Test of Civilization*

Varying Degrees of Ingenuity and of Technical Ability Shown by Savage Tribes

By Professor-Doctor K. Waule

ONE of the truest measures of the civilization of any race is to be found in its means of traffic, and this holds true both of highly civilized nations and of savage tribes and upon water as well as upon land. But while the most primitive and backward of native tribes manages to cover considerable distances on solid ground in the presence of the more difficult obstacles presented by streams and seas many groups of mankind have remained entirely helpless, being not sufficiently ingenious to discover or invent the simplest means for crossing stretches of water. Among such races are some few African tribes as well as most Australian ones, besides certain groups of South American Indians dwelling in the eastern Andes; these peoples have been obliged to compensate in a measure for the lack of bridges and boats by an increased skill in the art of swimming.

Both from the technical and from the ethnographic view point it is not without interest to study the primitive origin of bridge building, since this evidently presents a problem of more difficulty than that of making boats. The first bridges were undoubtedly the fallen trees lying across streams and the heavy vines or *lianes* crossing them. Such original bridges were discovered without difficulty. Man had only to follow the example of the animals in flight which chose such means of escape. In the case of the swinging vine, however, the problem is twofold, since the savage was called on to decide whether to cross it by means of his feet or by means of his hands. Here we have the problem of the stable equilibrium which any hanging body possesses when suspended from a rope, and the human observers doubtless took lessons from such animals as sloths and apes. The next step in advance concerned the problem of unstable equilibrium, one far more difficult to learn, and one with regard to which man probably found no natural teacher; it appears probable that under extraordinarily favorable circumstances and quite by chance a second vine happened to run above the first one in a slant line so that the first man who trod upon the dizzy road of the lower vine had a natural railing by which to support himself. The idea of such a natural railing or balustrade is a necessary concept which is proved by the fact that today wherever swinging bridges of vines are employed such a support is present. On the other hand, the implied difficulty of the invention and development indicate that these swinging bridges must have been of later appearance in technological history than the footpath across the fallen tree. Such swinging bridges are of rarer occurrence likewise and are practically confined to the dense primeval forest. An exception to this is found at the present day in the hanging bridges composed of thongs of skin known as *tarabites* and found among the Cordilleras of South America, for whose invention the same basic principle doubtless stood as sponsor.

FIG. 1. BRIDGE IN THE VILLAGE OF TIMBUNKE OVER THE KAISERIN AUGUSTA RIVER, NEW GUINEA. AFTER RECHE

The ancient bridge made of the trunk of a tree continued to develop in the form of the wooden bridge almost to the present time, but the first iron bridges were erected at Colebrookdale from 1773 to 1779, while the first German iron bridge was not built till 1794. Technologically speaking, the wooden bridge falls into three classes: Bridges of solid beams and girders, trestle bridges and suspension bridges. The latter rest exclusively upon vertical supports or A-frames. In the trestle bridges the footpath or carriage road is supported not only by vertical supports but by a system of inclined poles which interact upon each other. In the suspension bridge, finally, the roadway has sloping approaches and girders of very similar arrangement to the trestle bridge. In addition we may probably regard as the most advanced of the primitive forms the arched beam bridge of which we are able to present a very remarkable example.

The original form of the girder bridge is, as we have said, the fallen tree lying across the stream. When such a trunk happened to be smooth and unencumbered by branches it was ready to use at once; when this was not the case the primeval savage readily perceived that he must somehow get rid of the troublesome branches and twigs. The next step in development from the use of a tree felled by chance, as by storms or floods, and the felling purposely of a suitable tree in any desired direction was undoubtedly more difficult. We of modern times can hardly understand, indeed, how great was the necessity for skilful judgment, since we are provided for accomplishing the same purpose with long ropes and cables to pull the tree in any given direction as well as with sharp axes and saws, to say nothing of our long experience.

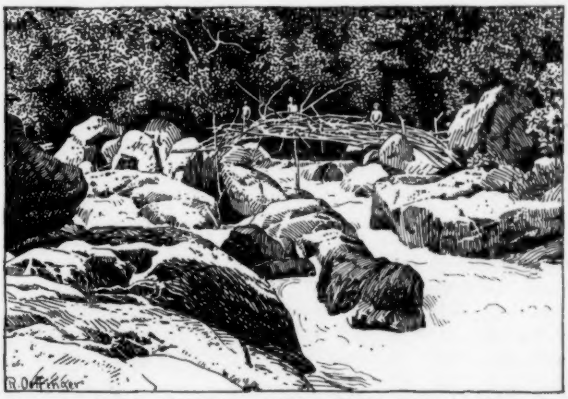


FIG. 2. VERY ANCIENT BRIDGE OVER THE ADULLA IN BRITISH NEW GUINEA. AFTER PHOTOGRAPH BY HAMANN

But such a bridge formed of a single beam or trunk demanded the keenest judgment to decide whether the length was too great for the supporting capacity or whether the diameter was insufficient, or whether to begin with, the stem of the tree was long enough to reach to the other side. In the former case the beam needed to be strengthened by sup-

*Translated for the *Scientific American Monthly* from *Kosmos* (Stuttgart) for June, 1920.

ports or yokes, whereas in the latter case the bridge required lengthening by the addition of one or more other beams, which in their turn had to be strengthened.

In this respect most surprising discoveries have been made by the members of the numerous expeditions which during the last few years preceding the war explored the Kaiserin Augusta River or Sepik in the interior of the great island of New Guinea. Little was known of the inhabitants of this interior region, since previous expeditions had confined themselves mainly to the coastal zone. All the more amazed, therefore, were the explorers to find along the winding river courses populous villages containing buildings with which the houses of our own German villages are unable to compete, either in architecture or in purity of style. Of a special stateliness are the ceremonial buildings with their gable roofs sweeping boldly to a height of 15 meters or more, and their length of as much as 30 meters. These structures, too, are gaily decked with color and are of great ethnographic interest —their inventory includes hanging brackets or hooks carved into all sorts of fantastic forms, from which depend various tools and household utensils. The great slit-formed signal drums and the bass drums shaped like an hour glass, together with marvelous representations of the animal kingdom in brightly tinted wooden structures, the richly carved white shields, etc., are full of interest.

FIG. 3. BRIDGE OF BAMBOO AT BUITENZORG, JAVA

Here, however, we will give only an illustration of the bridge in the large village of Timbunke, in interior Sepik. The architecture of this bridge appears to us quite simple, but when we consider the low degree of cultural development among the Sepik race it represents a very able piece of technical work. This is obviously quite aside from the degree of civilization of the constructors, since the Sepik like so many rivers of lowland regions has raised its bed above its surroundings so as to overflow the plain on both sides to a considerable height. When such an overflow occurs it takes place in an incredibly short time and the bridge builders were obliged to take this awkward circumstance into consideration; that they have done so is plainly seen in the picture from the height of the yokes, as well as from their construction with respect to the stream. The footpath—there is no question of a driveway in New Guinea—does not give the correct idea. However, we could reconstruct this for ourselves by imagining the orderly laying in place of the beams piled up in front of the bridge. As Professor Ruche, the official artist of the Sepik expedition, suggests, it is probable that the natives, taking alarm at the many strangers who had penetrated among them had removed the upper structure in part, so as to make a passage from one shore to the other considerably more difficult. The remainder of the bridge does not consist, as would appear from the picture, of a single beam, but of two beams lying side by side and with free-swinging ends. The waters thus bridged form a communicating canal between the River Sepik and the great back water swamp in the interior regions of Timbunke.

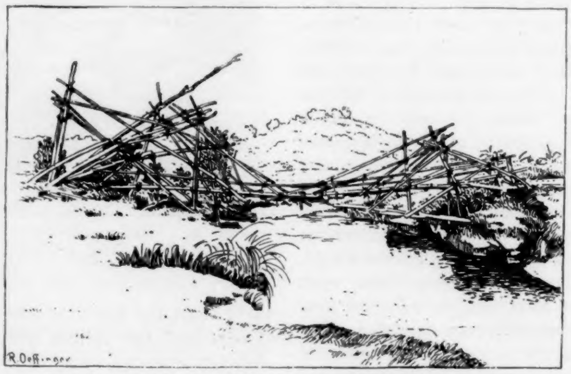


FIG. 4. BAMBOO BRIDGE AT RANTEPAO, CELEBES

Fig. 2 shows us a bridge in the eastern part of the same island in British New Guinea, in the country of the Mafulu. Judging from the appearance of these people and from their settlements, they must be an extremely primitive race. At first glance the structure made by them across the roaring waters of the Adualla River appears to be merely a sort of improved footpath or beam, but closer examination shows that we have here an instance of a true truss frame in which the main beams of the bridge are placed obliquely to each other from the banks, and at the intersections of the interlacing members are fastened to each other in crotches. For further strengthening the structure railings with uprights firmly attached to them, are employed, besides the longer poles which project from the railings to a rock in the river bed. As in all structures erected by primitive races, neither nails nor screws are employed, but the separate parts are all bound together by cords and ropes made of plant fibers. Even among the Malays, this method of binding is employed.

Fig. 3 takes us among the aforesaid Malays. It represents a foot bridge in Java in a comparatively civilized neighborhood. This explains the beautiful form of the entire structure, which otherwise is pure Malay. We have here a truss bridge with a suspended floor since the footpath is suspended in loops of rattan which ride at equal distances upon the beams which cross each other at the middle of the bridge. Upon the left side of the picture they run pretty much parallel to each other, which scarcely corresponds to the requirements of scientific construction; upon the other side, on the contrary, they appear to be parabolic like the footbridge itself and are, therefore, perfectly adapted to the required purpose. The pole supports which are anchored in the river bed are, undoubtedly, of more protection against wind and water pressure than of assistance in supporting the bridge itself. All the connections in this bridge of the different parts with each other are made, as is usual with the Malays, by binding with strips of rattan, etc.

A far bolder piece of construction is shown in the bridge represented in Fig. 4, located at Rantepao on the island of Celebes. It is believed, indeed, that in this bridge we actually have the forerunner of our modern steel and iron cantilever bridges. Even the indispensable anchorage demanded by such cantilever bridges is present here at one side, although it is lacking on the other. Here it is replaced by a couple of posts which represent to a certain degree the intrinsic character of cantilever construction. This hanging structure presents at first glance a shapeless confusion of bamboo poles. As a matter of fact, indeed, some of these, especially on the left side, are superfluous, but in spite of this the entire structure with its finely swung footbridge gives the impression of a well thought out technical job, not to be despised.

The other primal element of the bridge, *i.e.*, the vine stretched across the river has undergone a double develop-

ment, according to whether the swinging cable has been crossed by a man with his hands or with his feet. In the first form it had been developed into the rope path whose stages of development and area of application we will not here go into, though the subject is fascinating enough. The other basic principle has led in course of its development to the modern suspension bridge with its tremendously manifold forms and its often gigantic dimensions; it forms, indeed, in the technological history of civilized peoples an extremely important division, but it has by no means lost because of that fact its interest as regards the technical arts of the more backward races.

The simplest form of the rope bridge is the foot rope with a rope to act as a hand rail or balustrade running obliquely above it. It is hard to believe that anything so remotely ancient still exists. However, in its primitive form, this is the case as is shown by an interesting illustration which appeared in the *Technischen Rundschau* for April 24, 1907, and which is copied by G. Dieterich in his book *The Invention of the Wire Rope Road* (in German) published in Leipsic in 1908. This shows the proximity to each other of an old rope road and a still older rope bridge, both of which span a broad and rushing mountain stream in Kashmir, from one steep bank to the other. The rope road is made of ropes of raw hide about 3 cm. thick. The traveler takes his seat within a couple of rope loops or slings; these are attached to a fork-shaped piece of timber which glides along the rope. This sliding movement is produced by gravity alone, so far as the angle of inclination of the supporting rope permits; over the rest of the way there is a lighter traction rope which hangs in movable rings underneath the supporting rope and which is firmly attached to the sliding piece of timber.

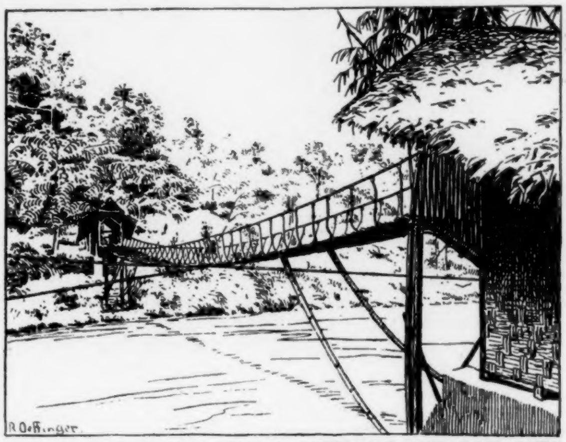


FIG. 5. SUSPENSION BRIDGE OVER THE TJIBADAK, JAVA

The rope bridge operates in a very peculiar manner; it consists of an extremely strong "hand rail" rope twisted together of a number of separate hempen ropes until it forms a cable almost 16 cm. thick, and of a foot rope running obliquely underneath the top rope at a distance of $1\frac{1}{2}$ meters and held in this position by vertical cables. According to our modern feeling the foot rope should be the stronger of the two but references in literature show that this bridge has been in use for an extremely long time, hence the system must have proved itself workable in practice.

The ordinary suspension bridge of modern times has hand rails on both sides; such bridges are found in the interior of western Africa and in New Guinea and elsewhere. This double hand rail not only makes the traveler more secure from a fall but at the same time strengthens the bridge not inconsiderably against the vertical load and the lateral wind pressure. From all accounts the most unpleasant, and at times even dangerous feature of the passage across such a bridge, is the lateral swaying of the foot rope. This statement is supported by the fact that a large percentage of rope bridges are provided with devices intended to prevent this sidewise swinging. In the collection of thousands of photographs in the Leipsic Museum, representing the arts of primitive people, there are dozens and dozens of such pictures of bridges, but among them there are comparatively few which do not exhibit some sort of an attempt at ameliorating the lateral swaying of the foot rope.

The most obvious method of accomplishing this is a lateral attachment of the bridge path and sometimes, also, of the hand rail which is firmly connected with the former to one or more firm and solid points on the bank of the stream above and below the bridge. In these attempts it is naturally not the resultant of the parallelogram of the lines of force which is employed, but only one component thereof, and the more acute the angle of the lateral attachment with the river bank the shorter this component; but these early builders have sought to remedy this disadvantage by a multiplicity of ropes. In the marvelously swung rope bridge shown in Fig. 5, which crosses the broad Tjibadak in Java, both pairs of bamboo rods on the shore abutments merely serve to strengthen the foot bridge, while the fine cords to the left and the right of these are meant to lessen the unavoidable lateral swing. Fig. 6, on the other hand, shows a rattan bridge at Rante Manuk in Celebes, in which both the strengthening of the bridge and the diminution of the lateral sway are achieved by the numerous *lianas* running obliquely upward from the hand rail to the trees crowning the lofty bank. The otherwise incomprehensible upward arching of the bridge exactly in the middle of the span is clearly explained as being due to the effect of the *lianas* or guy lines.

FIG. 6. RATTAN SUSPENSION BRIDGE STEADIED WITH GUY LINES, RANTE MANUK, CELEBES

FIG. 7. BRIDGE WITH STIFFENING HOOPS

In Fig. 7 we see a real masterpiece of technical bridge building, which is likewise a rattan bridge at Salo Manio in Celebes. Here the lateral braces have been entirely avoided in favor of a complete system of firm and compact rattan ellipses which are bound piece by piece to each separate strand of the hand rail and of the foot bridge at its intersection with them while above the upper end of the great axis there runs a main cable, which is likewise twisted of a specially

stout rattan *liana*. Further strengthening is secured by the interweaving of the hand rail and the footpath with finer rattan cords, apparently made of split rattan. Probably there is no other structure of this sort so admirably insured against vertical and lateral distortion. One receives a similar impression of a constructive masterpiece upon examining the wooden bridge at Osaka, Japan, shown in Fig. 8. Architecturally speaking it belongs not to the rope bridges but to th girder bridges; ethnologically speaking it forms perhaps the finest and most abstract example of that series of developments which we have observed in Figs. 2-4. In order to comprehend this we must recall that the modern Japanese are composed of very various anthropological elements, including a Mongolian element from the opposite mainland, a dash of Ainu blood, and an infiltration of Malay blood.

The Ainus are those very remarkable extremely hirsute dark-skinned people, who are confined in modern times to the northern portion of Yezo, to Sachalin, and to the majority of the Kurileu Islands, whereas before the arrival of the Japanese they occupied practically all of modern Japan down to the southern portion. The Malay immigration is readily explained by the former mobility of this race, who found little trouble in passing from their home in southeast Asia to Madagascar in the west and to Easter Island in the east, thus traveling over more than 200 meridian degrees, *i.e.*, distributing themselves over more than half the circumference of the earth. This Malay strain is borne witness to not only by the strongly marked Malayan form of the body, but also by the nature of the houses, whose original form, a structure of palings or posts, can be explained only by a southern origin, as also certain features in their bridge construction which likewise find a parallel in East Indian territory.

FIG. 8. ARCHED BEAM BRIDGE AT OSAKA, JAPAN

In the case before us the outer form is that of a bridge of arches. Unfortunately, the dark shadows in our picture prevent us from recognizing certain details of the construction, whereas the great original picture in the Leipsic Museum shows an extremely ingenious system of ties and wedges in which presumably nails and screws are as absent as in the original Malay bridges.

While these Japanese and East Indian bridge forms obviously point to a close connection, it is not so easy to answer the question as to the origin of like or similar constructions in the rest of the world. Where did the dwellers in the South American Cordilleras get their *tarabites?* Where did the inhabitants of the Cameroons and the primeval Congo forest come by their bridges of lianes? Where, finally, did our own ancestors obtain sufficient insight into the matter to enable them to pass heavy loads upon ropes or chains across abysses or to send men across rivers and arms of the sea on chain bridges? In his admirably conclusive book, *Zesammenhänge und konvergenz* (Connection and Convergence) published among the reports of the Anthropological Society of Vienna (Vol. XLVIII, 1918 (Vienna), Professor von Luschan answers this question to the effect that there is a historical connection between the development of the human race throughout the entire earth. He points out that the structures recently observed with so much astonishment in such isolated parts of the earth as New Guinea and western Africa have created false impressions; in reality rope bridges and rope roads are found in all parts of the earth so that they may be regarded as probably having a common starting point.

However, possible and even plausible this theory may be, the ethnographer, on the other hand, can easily take a stand upon the opposite standpoint: that individual invention in all those places where no connection with other phenomena of the same kind is provable or probable can be assumed. For example, it may be assumed from the double phenomenon of the rope road and the rope bridge that the repetition of this invention may be due to the simplicity of the basic idea; wherever it has been found a necessity to assume intercommunication it has been found possible to prove the fact.

The conflict between these two ideas among ethnographists has been much in evidence for many decades and the balance still swings between them.

RHINE-MAIN-DANUBE SHIP CANAL

The linking up of the North Sea with the Mediterranean by a trans-continental waterway was discussed in the court of Charlemagne in 793, and a commencement made, although subsequently abandoned.

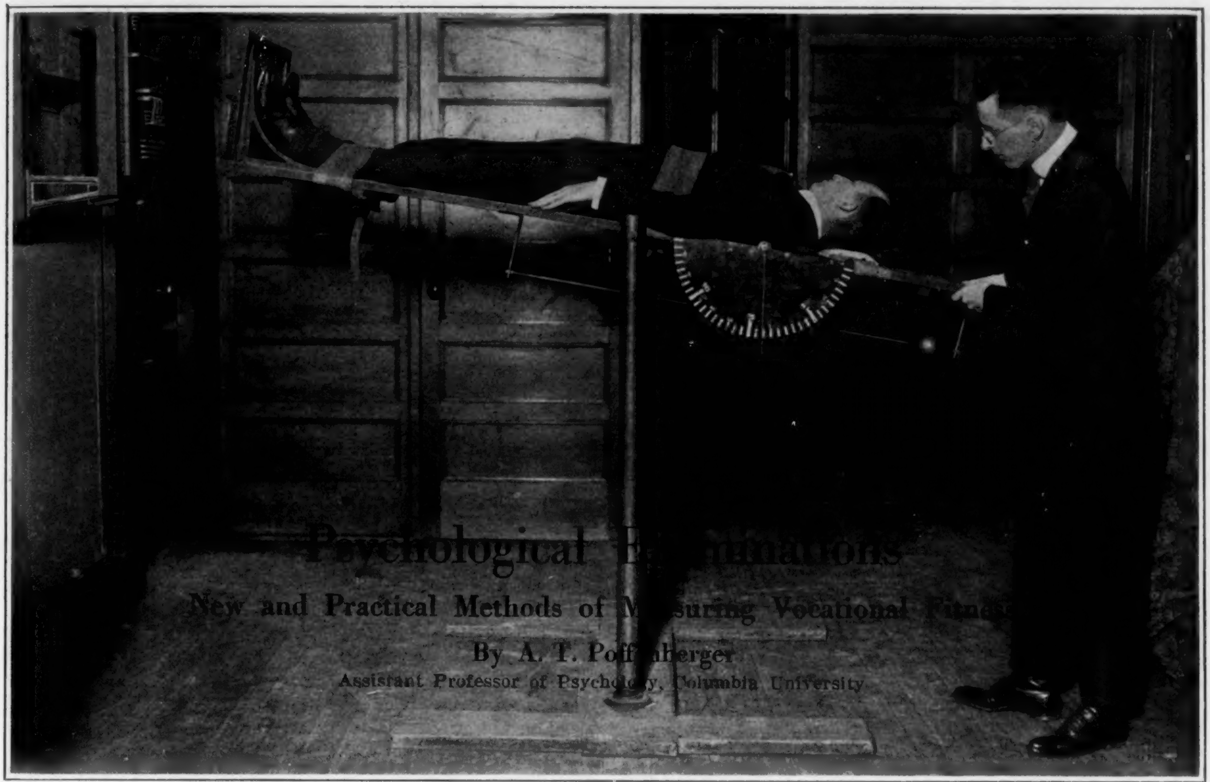
A canal connecting the Main with the Danube was actually constructed in 1836 by the Bavarian Government, but only for barges of 126 tons capacity. It has more than 100 locks, and is much too diminutive for modern transport requirements. The Bavarian Parliament voted 5 million marks in 1917 toward the cost of a new Main-Danube canal, which is to connect northern Bavaria with the Danube, and to be suitable throughout for ships 233 feet long by 33 feet wide, with 7 ft. 3 in. draught, viz., 1,200 tons burden. It is, in addition, to accommodate vessels of 1,500 tons burden, viz., 279 feet long by 33 ft. 6 in. beam, from the Danube to Aschaffenburg.

The total length of the proposed canal necessary to join the three rivers, including the length of the canalized river Main and Regnitz, is 451 English miles. The total rise to be negotiated above the sea level is 1,340 feet, requiring 60 locks. It is hoped to transport 12 million tons annually, the average time of transit to be 145 hours. Hydroelectric power to the extent of 168,500 hp. yielding 936 million kw. annually, will also be available. The estimated cost of the canal is 597 million marks.—Abstracted by *The Technical Review* from *Das Technische Blatt*, June 26, 1920.

JUNCTION CANALS FOR THE GERMAN HANSA TOWNS

The proposal to interconnect the three principal seaports, Hamburg, Bremen and Lübeck, with the four large rivers, Rhine, Ems, Weser, and the Elbe, by means of ship canals is now receiving serious consideration in Germany. The Inland or "Mittelland" Canal from the city of Hanover due west to the rivers Weser and Ems, merging into the Dortmund-Ems Canal and the Rhine, is practically finished, thus converting Hanover into a seaport communicating with the North Sea.

Five new inland waterways are deemed necessary: 1. A direct canal near Bremen to connect the rivers Ems and Elbe. 2. A direct canal from Brunswick to the Elbe, south of Hamburg. 3. A direct canal from Hanover to the Elbe near Hamburg. 4. A canal from the Mittelland canal at Osnabrück via Bremen to Hamburg. 5. A similar canal, also from Osnabrück to Hamburg, with branches to Bremen and Hanover, thus canalizing the river Weser.—Abstracted by *The Technical Review* from *Wirtschaftsdienst*, Sept. 23, 1920.



Psychological Examinations

New and Practical Methods of Measuring Vocational Fitness

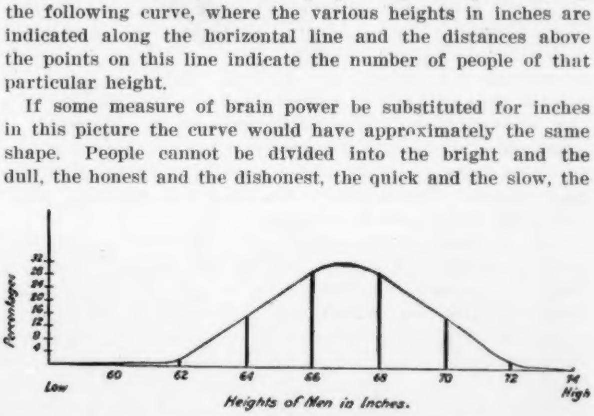
By A. T. Poffenberger
Assistant Professor of Psychology, Columbia University

TESTING THE LABYRINTHINE SENSATIONS BY MEANS OF THE TILTING TABLE

THERE is one fundamental fact underlying all psychological examinations, namely, that people differ in their mental capacities or powers just as they do in their physical characteristics, and that they should be treated according to their capacity. The popular notion, however, seems to be quite the opposite. The Constitution of the United States says that all people are born free and equal, and this is much more often interpreted to mean equal mentally than it is to mean equal physically. The notion of mental equality has been crystallized in our public school system. Only recently and in the most progressive communities have mental differences been officially recognized in school work and some provision made for the instruction of the mentally deficient and those who are unusually bright. The resistance that needs to be overcome in introducing such innovations bears witness to the strength of the equality belief. The many courses of instruction so widely advertised at present, most of them correspondence courses, which promise that any person taking them can become a $10,000 executive, play upon this same belief. The individual who believes that all people are equal in brain power and that only opportunity is needed for rapid advancement will welcome such courses of instruction. The large proportion of such enthusiastic students must be doomed to disappointment, because they are attempting more than their capacity will enable them to accomplish.

The verdict of the psychological laboratory is that men are by nature very different in every respect in which they have been measured; that these native differences are in part responsible for differences in achievement, how much cannot yet be determined; and furthermore that these native capacities determine the limit of achievement possible to every man. Mental capacity or what may be more popularly called "brain power" is distributed among the population very much as the physical characteristics of weight, height, etc., are distributed. That is, it is not possible to divide people into grades or classes according to height, as tall, medium or short; or according to weight as heavy, medium or light. There are all sorts of intermediate heights and weights, so that the tall and heavy gradually shade off into the light and short. The heights of all people may be represented by the following curve, where the various heights in inches are indicated along the horizontal line and the distances above the points on this line indicate the number of people of that particular height.

If some measure of brain power be substituted for inches in this picture the curve would have approximately the same shape. People cannot be divided into the bright and the dull, the honest and the dishonest, the quick and the slow, the sane and the insane. There are persons who represent all sorts of intermediate stages between these classes. A glance at the curve will show that there are more people of medium height than of any other height, and that the shorter the height the fewer people there are of that height; also the greater the height the fewer are the people who reach that height. The same is true of mental capacity. There are more people of average intelligence than there are of extremely bright or of extremely dull. It has been estimated that there are in the population about one-half of one per cent who are feeble minded. That figure would represent about the pro-



VARIATIONS IN THE HEIGHTS OF MEN[1]

[1]Reproduced from "Industry, Emotion and Unrest," by Edward Thomas, published by Harcourt, Brace and Howe.

TEST FOR MUSCULAR BALANCE OF THE EYES

Trying to make the two pictures blend into one in the prisms in the center of the table

THE COLOR PERIMETER TEST

This instrument is used to measure the field of vision and the color zones of the retina

portion of the people who are extremely bright. It is very convenient, sometimes, to think of people as being divisible into classes or groups or even of all people as being alike. It was necessary for commercial and industrial progress that certain standard forms should be adopted to suit a kind of average person. For example, chairs and tables and steps have been made a standard height, and other articles of daily use are made to fit a kind of hypothetical individual. But these physical standards have not been adopted without sacrifice on the part of the individual. Many short persons are forced to sit at their work in chairs so high that their feet cannot touch the floor, because chairs are made for the average person. But even here progress has been in the direction of giving greater consideration to individual needs. School seats, school desks, typists' chairs, work benches and stools are now made adjustable to suit the varied physical characteristics of the occupants. Much discomfort and injury to health are no doubt prevented in this way. It is impossible to estimate the damage that is being done in trying to fit mental abilities into a standard form, which can fit only the average person. The resulting lack of adjustment is responsible for many of our misfits in life. It has often been said that many a good carpenter has been spoiled in making a poor minister; the reverse is also true and the same statement will apply to every occupation.

The psychological examination, a device for measuring mental capacity, will ultimately be used to find the right work for each person to do, just as the footrule is coming to be used to find the most comfortable and satisfying chair for him to sit in. The psychological measure, however, is infinitely more necessary because the mental adjustments that need to be made are far less obvious than the physical ones, and are much less likely to be provided through common sense. The mental misfits are usually discovered when it is too late for readjustment, and for recovering what is lost.

Since natural differences are thought to be responsible for differences in achievement, the measurement of natural capacity occupies a very important place in psychological measurement. Intelligence is the term most commonly used to indicate this natural capacity and the tests for measuring intelligence have been most fully developed. But there are other natural traits that are not directly dependent upon intelligence but which are just as vital for success. These need to be measured. For lack of a better name we will call these "character traits" to distinguish them from the intelligence traits. They may also be thought of as moral traits as contrasted with the intellectual traits, and comprise honesty, integrity, sociability, kindness, ambition, etc. In addition to these two forms of natural capacity, certain more special capacities must be recognized and measured. Musical, artistic and mathematical ability, inventiveness, motor skill and the like are some of these.

On the basis of these natural capacities people acquire their general education and their special training. Although these attainments are limited by natural capacity, differences of opportunity make any perfect relation between capacity and attainment not to be expected. Hence, measures are needed for these acquired possessions. They are known as educational tests and trade tests. In addition to these forms of psychological examination, namely, the intelligence test, the character test, the educational test and the trade test, what might be called general fitness tests have been constructed and are intended to measure at once all of these traits. Each of these forms of psychological examination will be briefly described.

The best known and the most generally used of the intelligence examinations is the Binet Simon examination in one or other of its modifications. It consists of a measuring scale upon which the units are years of age and any person who is measured on this scale has an intelligence which may be expressed in terms of years. Each year unit on the scale consists of a group of tasks which are to be performed under carefully arranged and standardized circumstances. A few specimens of these units will illustrate their general character:

Second Month.—Occasional strabismus, recognizes human voice, turns head toward sound, pleased with music and with human faces. Laughs at tickling. Clasps with four fingers at 8th week. Uses first consonants.

Third Month.—Cries with joy at sight of father or mother. Eyelids not completely raised when child looks up. Knows sound of watch at 9th week. Listens with attention.

Fourth Month.—Eye movements perfect. Sees objects move toward eye. Joy at seeing itself in mirror. Opposes thumb. Head held up permanently. Sits up with support to back. Begins to imitate.

Fifth Month.—Discriminates strangers. Pleasure in crumpling and tearing paper, pulling hair, or ringing bell. Sleeps ten or eleven hours without food. Sounds consonants l and k. Seizes and carries objects to mouth.

Sixth and Seventh Month.—Raises self to sitting posture. Laughs. Raises and drops arms when pleasure is great. Teeth begin to appear. Astonishment shown by open mouth and eyes. Turns head as sign of refusal.

Eighth and Ninth Month.—Stands on feet with support. Claps hands for joy. Has fear of dogs. Turns over when laid face down. Turns head to light when asked where it is.

Questions understood before child can speak. Voice more modulated,

Thirteenth, Fourteenth, and Fifteenth Months.—Says "Papa and "Mamma." Raises itself by chair. Imitates coughing and swinging of arms. Walks without support. Understands ten words.

Sixteenth, Seventeenth, Eighteenth and Nineteenth Months.—Sleeps ten hours at a time. Associates words with objects and movements. Blows horn, strikes with hand or foot, waters flowers, tries to wash hands, comb and brush hair, and to execute other imitative movements.

Twentieth and Twenty-fourth Months.—Marks with pencil and paper. Executes orders with surprising accuracy.

Twenty-fifth to Thirtieth Months.—Distinguishes colors. Makes sentences of several words. Begins to climb and jump and to ask questions.

Thirtieth to Fortieth Months.—Goes upstairs without help. Clauses formed. Words distinctly spoken. Influence of dialect appears. Much questioning.

Third Year.—Can point to nose, eyes and mouth. Can repeat "It rains. I am hungry." Can repeat the figures 7, 2. Can enumerate objects seen in picture. Knows own name.

Fifth Year.—Knows which is heavier of two weights, 3 and 12 grams, and 5 and 15 grams. Copies a square. Repeats "His name is John. He is a very good boy." Counts four pennies. Can put together two parts of a rectangle cut diagonally.

Seventh Year.—Counts thirteen pennies. Describes pictures. Sees that pictures lack parts, such as eyes, nose, mouth, hands. Copies a diamond. Recognizes red, blue, green, yellow.

Ninth Year.—Makes change 20 cents less 4 cents. Gives real definitions to words in 6th year. Knows date. Knows the months in order. Arranges a series of weights correctly.

Eleventh Year.—Sees absurdities in certain statements. Makes sentence. Gives sixty words in three minutes. Gives words rhyming with day, spring and mill. Puts disarranged sentences together.

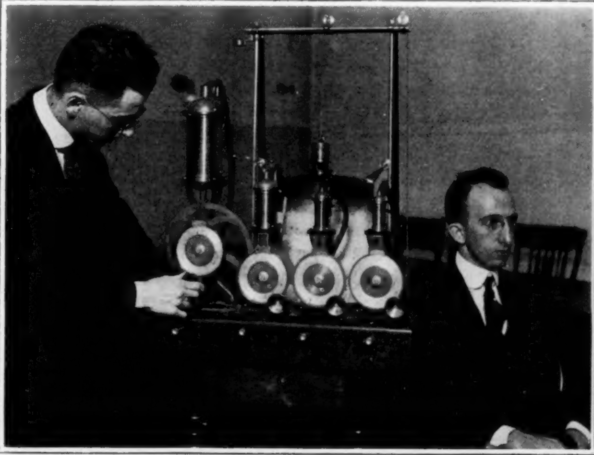
The tasks of each year unit are composed of a collection of things that the average child of that age can do as a result of living in contact with his physical environment and of associating with people but without special instruction. Now if a child of ten years can do all of the tasks up to and including those for year twelve, he is said to have a mental age of twelve; or if he can do all of the tasks only up to and including the age of eight, he is said to have a mental age of eight. This means simply that in the first case the child can do the things that the ordinary child of twelve years can do, and in the second case what the ordinary child of eight can do. If the child's mental age is expressed in terms of its relation to his physical age, we have what is called the intelligence quotient. Thus in the first case above, the child would have an intelligent quotient of 12 divided by 10 or 1.2; and in the second case an intelligent quotient of 8 divided by 10 or .8. When the intelligence quotient is above 1.00 the child is above the average intelligence for his age, and when it is below 1.00, he has less than the average intelligence for his age.

If the test really measures natural intelligence and not the mere product of education, the intelligence quotient, determined for the same child at different ages ought not to change. And this is just what the repetition of the tests seems to indicate. One of the greatest values of the intelligence test is just here, that it will enable the intelligence of the child to be determined very early and his career mapped out accordingly. If a child at the age of six is found to have an intelligence quotient of 1.30, it is a safe prediction that, barring the effects of accident or disease, he will as an adult be considerably above the average in intelligence.

This form of intelligence test, though of great service in measuring children up to the age of 14, has certain drawbacks when used to test adults. When the need for an intelligence examination in the army became apparent, because of the necessity for picking for responsible positions those who would be most competent after their special training, a new form of test was devised which was better adapted for the purpose. This examination can be given simultaneously to hundreds of people and can be scored by untrained persons. The tasks are not arranged in year groups, but in series according to difficulty. Each person does as many of the tasks as the time and his capacity permit. A certain number of points credit is attached to each sort of task, and the intelligence score is given in terms of a letter grade, A, B, C, C, C, D, D, E. This type of examination also measures natural capacity, and although some of the tasks call for specific information, it is such information as an individual of a given degree of intelligence would have acquired from contact with his environment and without special training. For example, some extremely high scores in the army were made by men who had not finished the eighth grade of school. This type of test is of particular interest because it has become the pattern for all of the more recently developed intelligence tests. Specimens of the different tasks follow:

Get the answers to these examples as quickly as you can.
Use the side of this page to figure on if you need to.

1 How many are 5 men and 10 men?.......Answer (15)
2 If you walk 4 miles an hour for 3 hours, how far do you walk? ....Answer (12)



STERN'S TONE VARIATOR—AN APPARATUS WHICH IS EMPLOYED TO TEST THE PERCEPTION OF TONAL DIFFERENCES

TESTING KEENNESS OF HEARING. THE SUBJECT MUST TELL HOW FAR THE WEIGHT FALLS BY LOUDNESS OF IMPACT

This is a test of common sense. Below are sixteen questions. Three answers are given to each question. You are to look at the answers carefully; then make a cross in the square before the best answer to each question, as in the sample:

SAMPLE
Why do we use stoves? Because
☐ they look well
☒ they keep us warm
☐ they are black

Here the second answer is the best one and is marked with a cross. Begin with No. 1 and keep on until time is called.

If the two words of a pair mean the same or nearly the same, draw a line under *same*. If they mean the opposite or nearly the opposite, draw a line under *opposite*. If you cannot be sure, guess. The two samples are already marked as they should be.

SAMPLES
good—bad....................same—opposite
little—small..................same—opposite

The words A EATS COW GRASS in that order are mixed up and don't make a sentence; but they would make a sentence if put in the right order: A COW EATS GRASS, and this statement is true.

Again, the words HORSES FEATHERS HAVE ALL would make a sentence if put in the order: ALL HORSES HAVE FEATHERS, but this statement is false.

Below are twenty-four mixed-up sentences. Some of them are true and some are false. When I say "go," take these sentences one at a time. Think what each **would** say if the words were straightened out, but don't write them yourself. Then, if what it **would** say is true, draw a line under the word "true"; if what it **would** say is false, draw a line under the word "false." If you cannot be sure, guess. The two samples are already marked as they should be. Begin with No. 1 and work right down the page until time is called.

SAMPLES
a eats cow grass....................true..false
horses feathers have all.............true..false

SAMPLES

2	4	6	8	10	12	14	16
9	8	7	6	5	4	3	2
2	2	3	3	4	4	5	5
1	7	2	7	3	7	4	7

Look at each row of numbers below, and on the dotted lines write the two numbers that should come next.

SAMPLES
sky—blue :: grass— **table** **green** **warm** **big**
fish—swims :: man— **paper** **time** **walks** **girl**
day—night :: white— **red** **black** **clear** **pure**

In each of the lines below, the first two words are related to each other in some way. What you are to do in each line is to see what the relation is between the first two words, and underline the word in heavy type that is related in the same way to the third word. Begin with No. 1 and mark as many sets as you can before time is called.

Notice the sample sentences:

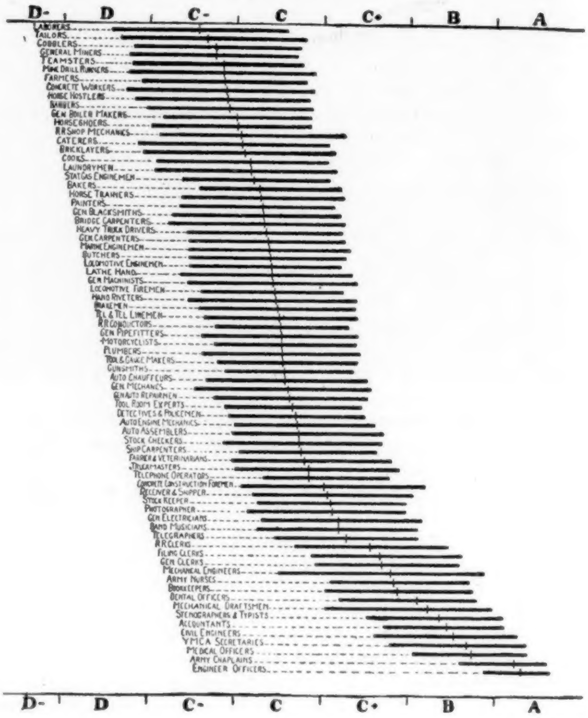
People **hear** with the **eyes** **ears** **nose** **mouth**

The correct word is ears, because it makes the truest sentence.

In each of the sentences below you have four choices for the last word. Only one of them is correct. In each sentence draw a line under the one of these four words which makes the truest sentence. If you cannot be sure, guess. The two samples are already marked as they should be.

SAMPLES
People **hear** with the **eyes** **ears** **nose** **mouth**
France is in **Europe** **Asia** **Africa** **Australia**

It is well to recall here that intelligence is not the only form of natural capacity and also that it does not necessarily measure the amount of specific information and special skill that may have been acquired. It is a legitimate question, then, to ask: What is the value of the intelligence task as a vocational guide, even if it is developed to perfection? The following chart taken from a report of the Surgeon General's office of the United States Army, showing the relation between intelligence and occupation in the case of 36,500 men, will help us in answering this question.



Low High

BRAIN POWER OF MEN IN DIFFERENT OCCUPATIONS[2]

Along the left-hand margin of the chart will be found the names of various occupations. The intelligence of the men in that occupation in the army is indicated by the horizontal line following each name. The length of this line and its relation to the A, B, C, etc., scale at the top and bottom of the chart shows the range of intelligence of the middle fifty per cent of the men in any occupation. For example, if the laborers are arranged in a row according to intelligence from the lowest to the highest, the first line in the chart will indicate the range of intelligence from the man one-fourth of the way from the bottom to the man one-fourth of the way from the top. The short vertical line cutting the horizontal line shows the intelligence of the middle laborer, namely C—. A casual examination of this chart shows that different occupations represent different degrees of intelligence. But it shows also that these differences among neighboring occupations on the chart are too slight to be of service in vocational selection. For example, the occupations from horseshoer to telephone operator all have the individual representing the middle of the group falling within the C class.

It is not by any means true that the best worker in any occupation is the person of highest intelligence. It is quite possible that for certain occupations a rather low grade of intelligence is adequate, and that to employ one of a higher grade of intelligence would be an economic waste. The determination of the minimum intelligence required to do satisfactorily certain kinds of work is an important problem, and the matter is being carefully studied. These studies may eventually enable the state to make its mental defectives economically independent by putting them into the type of work for which their capacity fits them.

Furthermore, intelligence is not the only trait required for

[2]Reproduced from "Industry, Emotion and Unrest," by Edward Thomas, published by Harcourt, Brace and Howe.

success in an occupation. Honesty, punctuality, loyalty, general health and many others may be indispensable. The best intelligence examination now in use for measuring fitness for entrance into college shows only sixty per cent of a possible perfect relation between performance in the test and academic record during the first year of college work. An authority on the use of such tests has stated that the relation could not be expected to be closer since success in college work depends on so many other traits besides intelligence. If that is true of college work, how true must it be of the majority of the vocations?

TEST FOR SPEED AND ACCURACY OF MOVEMENT AND STEADINESS

The needle makes an electric contact if it touches the hole. The thing is to put the needle in the hole without making contact

The measurement of these important traits of character, as we have called them, presents a difficult problem. Psychology has contributed somewhat to the analysis of these traits, but its main contribution consists in furnishing a method which shall make people's judgment about them more reliable. Such traits manifest themselves in a social environment only, in the behavior of one person toward another. Kindliness means the impression that we make upon other people in one respect, sociability, pugnacity, etc., the impressions that we make in other respects. They can mean nothing else. So to measure such traits we measure the impressions that others get of a person.

Psychological studies have shown several important facts about such judgments. First, there is safety in numbers. If one person's estimate of an acquaintance in regard to honesty has some reliability, the combined estimates of a dozen persons will have greater reliability. Knowledge of this one fact may do much toward improving methods of vocational selection. It has been found that if letters of application for a position are judged by ten people instead of only one, the combined judgments provide the more accurate measure of fitness. Second, some traits of character can be judged more accurately than others. To make a general statement about the matter, it may be said that those character traits which can manifest themselves in some objective form are most accurately judged, while the more strictly social traits are least accurately judged. Thus honesty and aggressiveness represent the former class and beauty and kindliness represent the latter class. Third, the estimate of oneself has some value. The statement has been made by one investigator that a person can judge himself better than anyone of his friends can, if he sincerely wants to do it. And he should be able to judge himself best in the traits in regard to which his friends have most difficulty in judging him. Sets of questions have been prepared with which anyone can make such a self-examination.

There has recently come to the writer's attention a system for vocation selection in which estimates are required for 350 separate traits and the final record for an individual is determined from one person's estimate of himself plus that of four of his acquaintances. This form of character judgment by oneself and his friends is quite different from the systems which depend upon the examination of anatomical features and proportions or upon snapshot observations of facial expression or more general bodily behavior. Such systems are based upon hypotheses that are not accepted by science. They flourish for lack of better ones, and simply bear witness to the great need of adequate measures of character. The degree to which one possesses a certain character trait is usually expressed in terms of percentages. For example, in what per cent of all the chances that one has to show benevolence does he really show it; of a hundred chances to show one's honesty, how many chances would be accepted? This is a very simple method of estimating. Another method, somewhat more elaborate, formed the basis for the rating scales used in the U. S. Army for estimating efficiency and other traits. Each rating officer prepares his own measuring scale for each trait as follows: In the case of "value to the service," he would put at the top of the scale the name of that officer who he thought possessed the highest value (100%); at the bottom of the scale he would place the name of that officer who represented a minimum value to the service (0%); others possessing intermediate degrees of value would be placed in appropriate positions between these extremes (25%, 50% and 75%). After the scale was thus formed, any officer could be judged by comparing him with the men representing the different points on the scale, and by giving the appropriate per cent rating. Ratings from a number of judges can easily be combined, for although the points on the different scales are not represented by the same individuals, still they represent for all judges the same degrees of value. These measuring methods are being introduced into business and industrial organizations.

Tests for measuring *special* natural traits or capacities were the first to be developed. Francis Galton, as early as 1880 prepared a test for measuring capacity for getting mental images of objects. Following Galton there were devised special tests for attention, perception, speed and accuracy of movement, keenness of vision and hearing, sensitivity to changes of position of the body, sensitivity to color, to differences in the pitch of tones, etc., until today there are hundreds of them.

MEASURING SPEED OF REACTION WITH THE HIPP CHRONOSCOPE

The interval between the sounding of a signal and the touching of a key by the subject is measured in thousandths of a second

Many have special significance for vocational fitness and are used in the selection of typists, stenographers, clerks, salesmen, telephone workers, railroad engineers, and machine workers of various sorts. The accompanying photographs show some of these tests being administered.

Many of the tests for special capacity are so-called paper tests, because the only materials needed are pencil and paper. Brief samples of these will illustrate their nature:

Number Checking Test in Which Certain Numbers or Pairs of Numbers Are to Be Checked as Rapidly as Possible

Form A

4 5 8 7 9 2 3 6 0 1 7 4 1 **8 6 0** 5 9 2 3 5 9 6 0 8 4 2 3 1 7 8 2
1 3 0 7 5 6 4 9 4 5 8 2 7 6 3 9 0 1 7 6 0 8 4 3 9 5 1 2 1 9 4 7 2 5
0 8 3 6 3 6 4 5 7 0 1 2 9 8 6 **5** 2 8 3 9 4 0 1 7 2 3 7 6 9 4 1 8 5 0

Form B

215864	**381592**	**826739**	**967814**	**371245**	**942861**
876395	**269517**	**712983**	**368459**	**326748**	**258647**

Directions Test, in Which the Printed Directions Are to Be Followed as Quickly as Possible

1. Write any number larger than 16
2. Add one more dot to the largest group • ••• ••
3. Put a cross over the angle that opens downwards ∨ ∧

Addition Test, in Which Each Number Is to Be Added to the Following Number or 17 to Be Added to Each Number

Kraepelin Form	*Constant Increment Form*
4	32
9	47
3	21
8	53
6	39
5	28
2	65

Association Tests in Which the Part of Speech Required by the Instructions Is to Be Supplied as Quickly as Possible

Opposite Tests

better
glad
straight

Logical Relation Tests

vb-obj	*supraord*	*subord*	*pt-wh*
cut	horse	flower	roof
buy	Paris	lake	tail
bend	potato	game	Germany

wh-pt	*agt-act*	*act-agt*	*att-subst*
wheel	train	shines	cold
Europe	frog	howls	cheap
brush	sun	crawls	narrow

Mixed Relations Test

Box—square	Orange—
Woman—husband	Man—
East—west	Day—
Penny—copper	Nail—
Asia—China	Europe—
Grain—sand	Drop—
Am—was	Have—

Free Association Test

fox	grass
apple	quick
fork	cure

The great difficulty that is met in preparing tests for special abilities is to determine just what special abilities are required to do a given task. What to the layman may look like a very simple operation may from the psychological point of view be divisible into fifteen or twenty special functions. We are accustomed, for instance, to speak of musical ability as a kind of special possession. The study of this ability by a psychologist has resulted in its division into at least thirty-five special traits, each of which is of importance in determining the musician's ability. Tests for these traits have been standardized and some of them have been arranged on phonograph records, so that anyone can without particular training get an approximate measure of his sensitiveness to differences in pitch of tones, his sense of rhythm, his memory for tones and his sense of harmony. If the records of a person in these tests are expressed in terms of per cent of the maximum degree to which this trait may be possessed, a chart may be constructed which will show at a glance a kind of picture of his capacity. Such a chart is called a psychograph, and a short psychograph of musical capacity is shown in the accompanying figure.

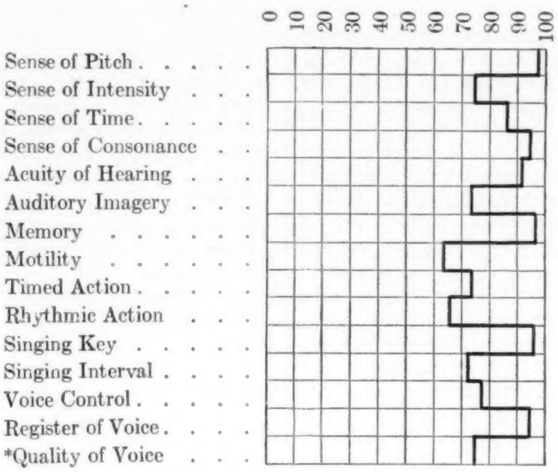
MEASURING FATIGUE BY MEANS OF THE MOSSO ERGOGRAPH TO TEST MAN'S ENDURANCE

The work of telephone operator may be similarly broken up into a group of special abilities, and the psychological tests devised to measure them may bear little or no resemblance to the actual work done by the operator. Some of these tests are the perception and association tests previously described. In some cases the work defies psychological analysis and a different method of testing has to be resorted to. A large number and variety of tests are prepared and tried upon operators of various grades of ability as measured by their actual performance in their work. Those tests which the good

THE GALTON BAR WHICH IS USED TO TEST THE PERCEPTION OF SMALL DIFFERENCES OF LENGTH

operator can do well, and which the poor operator can do only poorly, and which the average operator can do moderately well are chosen as measures of this particular capacity. This is known as the correlation method. It is a strictly empirical method and rests upon no previous analysis of the job. Many splendid results have been obtained by this method in measuring complex capacities as stenographic ability.

The remaining types of tests, the educational and the trade tests, are psychological only in the sense that the methods that are used are psychological. The ordinary school examination, if the questions are prepared and the answers scored according to psychological principles become psychological tests. The information and skill tests which are becoming so



A PSYCHOGRAPH OF MUSICAL CAPACITY[3]

useful in industrial work are psychological in this sense also. The measures of native capacity are, however, most commonly thought of as psychological tests. There are so many forms and varieties of mental measure that one can no longer speak of "the psychological examination," but must distinguish some special form of it. Every conscientious writer upon the subject of mental measurement realizes that the study and preparation of such tests has only begun, and feels constrained to warn against expecting more at present than can be accomplished. No one familiar with the field of mental tests doubts the position of importance they will occupy in the future. The only danger at present lies in the indiscriminate use of the tests by persons not qualified to administer them and in cases where their application is not justified. As measuring devices for a serious purpose they can be used only by those who understand their nature and recognize their limitations.

SPEAKING WITHOUT A LARYNX

SINCE the larynx is the chief organ of speech it might well be supposed that its loss through accident or disease would involve muteness. However, a French physician, Dr. Sébileau, an associate professor of the Paris Faculty of Medicine, recently exhibited one of his patients to the Society of Surgery, whose larynx he had entirely removed some fifteen years previously. The patient had retained of his entire physical apparatus, only the resonance chambers. Yet singular as it may seem the victim of this misfortne had acquired the power, after five years of steady effort, of speaking well enough to be understood without trouble and with sufficient force to be heard at a distance of 10 to 15 meters.

Dr. Sébileau explained to his audience that since the pulmonary apparatus is unable to act as a reservoir of air, this function is fulfilled by the activity of the pharynx, and possibly even by the œsophagus and stomach. The supply of air is probably obtained by swallowing. In order to transform the activity of the œsophagus and pharynx into that of a bellows and to maintain therein the air at a pressure capable of producing physical sounds approximate to normal, the indispensable hermetic occlusion is obtained by bringing near each other the epiglottis, the base of the tongue, and the pharyngeal muscles. When he wishes to talk the subject first presses the base of his tongue vigorously against the velum and then lowers it suddenly, giving an exit to the air enclosed within the pharyngeal cavity, while the epiglottis, the posterior columns, the lips and the tongue perform the motions required to enable the cavities of resonance to perform their usual function. In Dr. Sébileau's opinion the posterior columns of the epiglottis act as vocal cords. During the utterance of the open vowel *a*, for example, the columns and the epiglottis are held taut and possess a vibratory movement; they thus help to form the fundamental note which is then modified by the harmonies of overtones produced by the cavities of the mouth and nose.

The voice thus produced is not quite natural in sound, it is rather hollow sounding because of the insufficiency in the character of both the fundamental and the overtones. The epiglottis and the palate and its movement form a long soft reed pipe and this produces a tremolo voice. Furthermore, the subject is unable to modify either the timbre, the height, or the intensity of the sound. He is unable either to whistle or to whisper—however, he is able to blow out a candle.

Two interesting deductions are derived from this case. In the first place it seems evident that persons having suffered such an injury can recover their power of speech to a considerable extent by undergoing a special training. Furthermore, the case shows that speech is a more complex phenomenon than had been supposed, it indicates, for example, that the upper respiratory passages play a much larger rôle in speaking than had been thought. Light is thrown, too, upon the imperfections exhibited by the speech of certain deaf mutes, who have been artificially trained to speak. Perhaps, too, we have here the key to the theories explaining the much debated phenomenon of ventriloquism.

THE THERAPEUTIC VALUE OF SILICIC ACID

A GERMAN physician has recently directed attention to the remarkable curative action exerted upon wounds by silicic acid. Writing in the *Zeitschrift für Balneologie* he observes that numerous experiments have firmly established the fact that silicic acid, which is always present in the body, is very closely related to connective tissue, so closely related, in fact, that the content of silicic acid in the organism is directly dependent upon the amount of connective tissue present and *vice versa*. Hence the silicic acid may be regarded as the chief means of functioning of active tissue. But the silicic acid of the body not only stimulates the formation of active tissue but also greatly increases the number of white blood corpuscles or leucocytes. It is a well-known fact that the leucocytes possess two important functions with regard to the preservation of the health of the organism. By their phagocytic power they directly destroy bacteria which have succeeded in penetrating the body and, furthermore, they produce protective substances called leucines in the tissue fluid which also have bacterial action; the greater the number and the more rapid the production of the white blood corpuscles the more active is the passage of the leucines into the tissue lymph. In spite of aseptic treatment wounds often become inflamed for one reason or another, and in such cases the addition of silicic acid is found to exert a very favorable influence upon the process of healing. The investigator remarks that among the various preparations of this acid, none so far has been produced which is entirely free from objection, consequently he advises its use in the form of its solution in natural mineral waters.

[3]Reproduced from the Psychology of Musical Talent, by Carl Emil Seashore, published by Silver, Burdett and Co.

Chemical Construction and Individuality*

New Light Thrown Upon the Enigma of Specificity by Chemical Analysis and Research

By H. Bierry, D. Sc.

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ONE of the characteristics of living creatures is their individuality. Even if there is practically no difference between two living beings, their individuality is, nevertheless, discernible; in other words, they form two distinct entities. Even though an organism must develop along a definite line indicated by the heredity which obliges it to reproduce a type of its race, it none the less remains a definite unit, distinct both from its ascendant relatives and from its descendants. . . .

Living organisms may be considered from two points of view—that of their form and that of the concrete qualities concerned in what we call "life." For a long time it was the form alone which was the subject of special study; as a matter of fact, indeed, there is nothing which gives a better idea of the individuality of the living creature than the typical form it possesses. Thus we find that, to begin with, the sciences of zoölogy and botany devoted themselves exclusively to the study of descriptive characteristics: the external configuration, on the one hand, and the internal or *physical structure*, on the other. The next step was taken by general physiology, which revealed to us the existence of a common foundation forming the basis of living forms under various disguises. Finally, chemical analysis by showing individual variations of composition has revealed the vast importance of *chemical structure*.

It was Armand Gautier who first brought this subject into the field of experiment by his researches with respect to *Vitis vinifera*, finding in the different chemical nature of the constituents of cells, the profound causes of those morphological diversities which the naturalist classifies in his ideas of species, families and races. This view is shared, likewise, by A. Prenant and E. Lambling. La Dantec is of the opinion that there is "a definite relationship between specific form and chemical composition—in other words, that the chemical composition indicates and directs the specific form taken by the organism." In a recent book Jacques Loeb states his conclusions concerning this matter in the following words: "Specificity is determined by specific proteins, while at least some of the Mendelian characters appear to be determined by hormones or by enzymes which are not specific for the species or for the genus."

But even if the problem of the living *form* as held by Albert Dastre cannot be entirely reduced to the same terms as the problem of living *matter*, even if this form must be considered to represent "the condition of material equilibrium corresponding to a very complex situation, to an ensemble of given conditions," in the present state of scientific opinion, it is difficult to avoid the assumption that the chemical condition must be a factor of preponderating importance and that the specific form of the organism must be connected, at any rate in very large part, with the chemical structure.

Even if all vital functioning is merely, as is believed, the resultant of intimate actions in relation with the integrating molecules of protoplasms and the state of so-called "activity" of these molecules—for it is only in some such manner that we can conceive of elementary phenomena—it is, nevertheless, quite possible to believe that specificity or individuality is more or less chemical in nature not only as regards function but with respect to external aspect. According to this theory, changes of form must result from molecular modifications—in other words, it is through the nature and the arrangement of the molecules which constitute the elements of the structure that we must seek to understand the peculiar functioning of the various tissues.

Having once accepted this point of view one is tempted to go still further and to inquire whether there may not be some analogy of configuration between the organic elements and those stimulating secretions or excitants, some of which have an indisputable analogy of configuration[1]; in other words, one which may be compared to that held by E. Fischer to exist between the diastase and the asymmetrical body[2] which the former attacks. We should have difficulty, indeed, in forming a concept of the definitely elective action exerted by the hormone, except through this idea of an analogy of structure between the anatomical substratum and the corresponding hormone. How otherwise can we explain the extremely delicate sensibility of certain muscular or nervous fibers to the action of chemical substances (Dale and Laidlaw) which merely approximate certain groups of atoms.

But let us return to the subject of our special concern and seek to discover among the numerous component elements of living creatures whether there be not some substance or some group of substances which may be considered as forming the basis of specificity, *i.e.*, by which the individual is characterized.

The works of Hopkins, of Osborne and Mendel, and of McCollum have demonstrated, by establishing the close relations

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[1]A striking illustration of the part played by a given group or a given function in the molecule of the chemical stimulant is afforded by the effect exerted upon the terminations of the sympathetic nervous system by adrenalin and analogous substances (arterenol, adrenalone, etc.) which are classified as being more or less "sympathomimetic," according to the degree in which their structure approximates that of adrenalin. . . .

Abderhalden's studies with respect to cases of true hermaphroditism are still more suggestive. Certain pheasants have been produced whose plumage is that of the male upon one side and that of the female upon the other. On that side of the bird having the male plumage there is a testicle while upon the other there is an ovary; but it is a well-known fact that the secretion of these two organs exerts a direct influence upon secondary sexual characters and upon the plumage in particular. It is quite certain that these two sorts of secretion are furnished indiscriminately to each side of the body of the bird and we are obliged to believe as E. Lambling has pointed out that the chemical nature of the protoplasm plays a definite part in the matter; but it is difficult entirely to explain the fact unless we assume that there is an analogy of configuration between the anatomical substratum of the male side and of the female side respectively, and the corresponding stimulant secretions.

[2]There are a number of diastasic actions which require a close collaboration between the enzyme and some special chemical substance, as in the case of Laccase and manganese, trypsin and calcium, amylase and electrolytes, maltase and the chlorine ion, etc. *By analogy we are justified in supposing that certain special chemical substances are required for the action of certain hormones and that certain vitamines may play such a part.*

Let us consider in this connection cases in which animals are supplied with food entirely lacking in vitamines: In the first phase of the experiment no particular symptom and no characteristic disturbance is to be observed; afterwards in the second phase the symptoms of avitaminosis appear, including lack of appetite, nervous disturbances, troubles of metabolism, a lowering of the temperature, etc., while, at the same time, there is an atrophy of all the organs except the supernal glands which exhibit on the contrary, a marked degree of hypertrophy . . . but all of these sysmptoms can be made to disappear in the course of two or three days, provided that suitable vitamines are supplied. . . . These facts are readily explained if we suppose that the vitamines play a definite part in the action of certain hormones. . . .

Apparently the vitamines present in various animal tissues are to be regarded merely as reserves capable of being utilized by the organism. The creation of vitamines appears to be accomplished solely by certain bacteria (Bottomley, H. Bierry, and P. Portier, Pacini and Russell).

which exist between the growth of an animal and the molecular composition of the alimentary albumens, that evolution has been governed up to a certain point by chemical structure; however, experiment has not proceeded further along this path. It is only when we turn our attention to the comparative biochemistry of species and of tissues that we can succeed in finding groups bearing the specific imprint or trade mark, so to say, belonging to the species, since hitherto it has been found impossible to modify specificity by experiment in any permanent fashion. It is true, perhaps, as Schaankervitsch holds, that it is possible by modifying the external milieu to transform the *Artemia salina* into the *Branchipus stagnalis*—but this fact is a matter of dispute.

BASIC ELEMENTS OF ORGANS AND TISSUES

According to the accepted belief the fundamental elements of organs and tissues consist of protein, fats, and carbohydrates combined with each other and with mineral substances: glyco-proteids, lipoids, nucleo-proteids, etc. We also find within the tissues the products of cellular activity—the hormones and the diastases.

If we suppose that the general chemical specificity of an organism is composed of all the special chemical specificities possessed by the various differentiated tissues, then it would seem at first glance that the nucleo-proteids which form a portion of the nuclear chromatic substances and of the chromosomes (. . . which are regarded as the carriers of hereditary characteristics) ought to exhibit remarkably definite chemical properties. But this is not the case.

The methodical laboratory tests made by Levine to which we owe our most recent information concerning the "*nucleotids*" have shown that the nucleins, the lipoids, which are present in all the organs of all the species, and the conjugated sulphuric acids . . . exhibit an invariable structure. Consequently, Levine seems driven to admit with Jacques Loeb that these bodies do not determine specificity and are not the carriers of the Mendelian characters.

The Albumens.—This brings us to a study of the albumens, which are held by Loeb to be the "carriers of the specificity," and among the various albumens in the body he examined particularly those of the *vital milieu* also known as the *internal milieu.*

This milieu, which in complex organisms consists of the blood, the lymph, and the interstitial liquids in which are immersed the actually living protoplasms, is definitely distinct from the *cosmic milieu* or *external milieu;* this internal milieu also exists, but in a much less complex form among many of the protozoa and the bacteria. The higher the organism in the scale of life, the more fixed the nature of this vital milieu and the more independent it is of the external milieu; because of this very degree of perfection its physical and chemical composition in the higher organisms is capable of varying only between narrow limits. . . . This is what we mean when we say that each individual has its own *specific milieu.*

While the cosmic milieu is the common environment of all creatures each separate organism must elaborate its own vital milieu. Indeed, one of the peculiarities of living creatures is their capacity for synthesizing their own peculiar substance from foreign elements, and in particular from the albumens of the *blood plasma.*

The Sanguine Plasma.—From an anatomical point of view the plasma is a saline liquid containing albumen and sugar and holding in suspension the red and white corpuscles—thus constituting the blood. From the physiological point of view it is the medium which enables the organism to make exchanges of matter between its own organs as well as with the cosmic milieu. It receives the materials of nutrition and delivers them to the various tissues; the latter, in their turn, pour forth into the plasma the various products which they have elaborated, together with the waste matter which must be got rid of. . . .

Upon analysis, as we shall see, the plasma is nearly always found to be composed of the same basic substances in practically constant quantities. This uniformity is obtained by means of the very delicate and perfect mechanisms which strictly regulate its composition. This uniformity of constitution is only approximate, however, since the immediate principles which form the tissues are constantly undergoing disaggregation, while new amounts of the same substances obtained from outside sources enter the plasma and are introduced into the eternal cycle of vital operations. These two processes of destruction and renewal are always associated and reciprocally operative.

The plasma, then, is the milieu wherein there is an equal equilibrium constantly aimed at between the new materials provided and the used up materials of worn-out structures.

Let us now consider certain experiments which have revealed to us the fixed nature and proportions of the albumens of the plasma. In one experiment a horse was freely bled a number of times, being fed between times with a special albumen called gliadine, containing 45 per cent of glutamic acid; yet at the last bleeding the proteins in the plasma of this horse contained merely a practically normal percentage of glutamic acid (Abderhalden).

But it is even possible to go still further and to remove from an animal a really enormous quantity of plasma provided there be injected without too long a delay, corpuscles in a physiological saline fluid; in the case of a dog bled in this manner the plasma is found to have regained its normal content of proteic substances at the end of two days, and this even when the dog had received no food (Morawitz).

It is evident that the organism must have at its disposal very varied resources to enable it thus to keep its plasma supplied with an adequate amount of albumenoid substances in spite of a great diversity of food and even in spite of actual starvation. . . .

Formation of the Albumens.—After *digestion* which consists largely of a methodical cleavage (though it has not been proved that the molecular dislocation is entire), and *assimilation* the various fragments first form peptid combinations and then suitable albumens of various forms capable of taking part in the activities of the body: protoplasmic forms meant for the reconstruction of cells or the formation of new cells, plasmatic forms constituting the internal milieu, and special forms which have been described by Voit and by Rubner. Among the elements prepared by the digestive process and transported by the blood, the various tissues chose what they need and produce certain transformations (Van Slyke and Meyer, Folin and Denis). It must not be forgotten that the degradations of the proteins of the fats and of the carbohydrates occur simultaneously, so as to produce substances which react upon each other, so that we must consider the albumenoids of the blood plasma as resulting from a reconstruction of the products of digestive hydrolysis subsequent to the exchanges and combinations which occur within the tissues.

A proof of these complex combinations is found in a hydrocarbon group in the proteins of the plasma, which has been found, even in an animal fed only with proteins deprived of the sugar group—and even, in fact, in an animal which has received no food at all. This indicates that we must not regard the albumens of the blood plasma and the albumens of certain tissues as being "neutral" proteic substances, as has been held; we must look upon them on the contrary, as substances possessing many chemical affinities and always ready to take part in chemical reaction. We must think of these molecular structures, therefore, not as rigid blocks, but as plastic combinations, whose stability is governed by reciprocal balances, and which are, by that very fact, fitted to play their part in the incessant mutations which occur within the organism.

Let us next inquire whether digestion and assimilation result in the formation of albumenoids specific to the species, and, more particularly, to the individual.

The organism does not allow its vital milieu to be entered except by materials which have been deprived of the specific characters of a foreign species whence they proceed; furthermore, it tolerates only substances presenting an adequate form . . . if, for example, we introduce in a roundabout manner into the internal milieu of an animal, nucleo-proteids derived from the albumens of foreign tissues or even from the tissues of the animal itself, substances which would produce no trouble when swallowed *per os*, disturbances at once occur and what are known as "cytotoxic functions" immediately make their appearance in the plasma, forming an indication of the presence of the corresponding *diastase of defence* (H. Bierry and A. Pettit, Pearce, Fiessinger). We may look, therefore, to find a specificity in the albumens of the plasma, a fact which is betrayed by certain biological reactions including phenomena of precipitation and of anaphylaxis.

It is a well-known fact, on the one hand, that when we inject, a number of times, under the skin of an animal an albumen borrowed from a different species—if we inject a rabbit with horse serum, for example—then the serum of the animal which has undergone the injections will acquire the power of precipitating the injected albumen. This reaction is called the *formation of precipitine*, but this precipitation is *produced only by the serum of the horse*, it is not produced by proteic substances other than those contained in the serum. *However, a rabbit serum which precipitates the albumen of horse serum will also precipitate the albumen in the serum of an ass or of a mule.*

Moreover, if we inject horse serum into the veins of a rabbit no disturbance occurs, but if the injection is made into a rabbit which has previously received horse serum injected beneath the skin (two or three injections a week apart) disturbances are produced which bear the name of sero-anaphylactic disturbances and which may be serious enough even to cause death.

These biological experiments clearly show that there is a *zoölogical specificity*, a specificity of origin—*i.e.*, the definite mark imprinted by the species—in the albumens of the blood plasma. By modifying certain proteins by the action of various substances, such as diastases, oxidizing agents, etc., and employing them in the biological tests described above, we can produce or not produce, as the case may be, these reactions of precipitation or of positive anaphylaxis. Thus certain primary proteoses, which have retained the amino acids of the primitive molecule with their particular grouping, do not react in this manner; this affords proof that these biological reactions are determined not only by the presence of certain groups in the molecule but by the configuration of the said molecule itself.

Having proved our first point let us now inquire whether there be in the composition of the proteins of the plasma some element or group of elements which varies constantly according to the species and to the individual, and which we may, therefore, consider as being a *biological characteristic*.

Glucose.—Glucose is found in the blood plasma of man and of various animals including mammals, birds, reptiles, batrachians, fishes, etc., in two forms—in a natural state and in a state of combination. In the latter case its presence cannot be manifested until after the breaking up of the complex molecule which contains it and which adds its aldehydic function. These are the proteins of the plasma whose molecules contain the combined glucose which is known as *proteidic sugar*. This proteidic sugar exists in greater or smaller amounts in the albumens of the various sorts of plasma and it is possible to prove that there is a definite relation between the percentage of this proteidic sugar and the amount of nitrogen contained by the proteic substance; hence this percentage can be used to calculate the entire amount of the aforesaid substance.

Special research upon this subject has shown that *each animal species possesses a blood plasma consisting of a special albumen*, as can be shown by a study of the ratio of the content of the proteidic sugar and the nitrogen, which differs for each species (H. Bierry and Albert Ranc).

This ratio determined for arterial blood is approximately 3 in fowls, 6.5 in horses, and 8.5 in dogs; it varies in much more narrow limits in individuals of the same species—for example from 2.9 to 3.5 in fowls, from 6 to 7 in horses, from 8 to 9 in various dogs—but it exhibits in the same individual a manifest constancy, at any rate at intervals of several months and under the same conditions.

Special Albumens and Individual Plasmas.—We are justified in stating, therefore, that the plasma of each individual contains a given percentage of a special albumen, suggesting that the organism supplies its various cells not only with proteins of a special nature but with definite proportions of these—that there is, in a word, an *individual threshold*. There is such a threshold likewise in the higher organism for water, for fatty and lipoid substances, for free sugar, and even for temperature; we also find in these higher organisms an entire series of functions designed to maintain physical and chemical conditions. "These vast synergetic actions," writes Albert Dastre, "which must be regarded as primordial functions—respiration, circulation, and the excretion of waste matter, find the reason of their existence in the regulation of the internal milieu."

This is the *law of constitution of organisms* enunciated by Claude Bernard. According to the view held by this authority, nutrition, taking the term in its widest sense, requires first an organism—atavistic protoplasm—and a suitable milieu, and life is the result of the conflict between the living particle and the medium which surrounds it. But in direct proportion as we advance in the scale of life, we find an increasing stability of the vital milieu as compared with the anatomical elements whose protoplasmic composition is likewise perceptibly fixed; this slight variability of the two factors of the so-called "vital conflict" forms an expression of the close chemical bonds by which they are united and which permit the passage from one to the other of the proteins in particular. This suggests indeed the existence of common chemical nuclei.

The idea of the specificity of the plasma carries with it the idea of the varieties of plasmas equal in number to the variety of species and of individuals. Together with a common vital basis, the individuals of the same species may exhibit plasmas differing from each other by infinitesimal shades. Conceding this to be true there is no better way to define the individual than by a knowledge of its vital milieu, since strictly speaking there is none other which is precisely the same. . . .

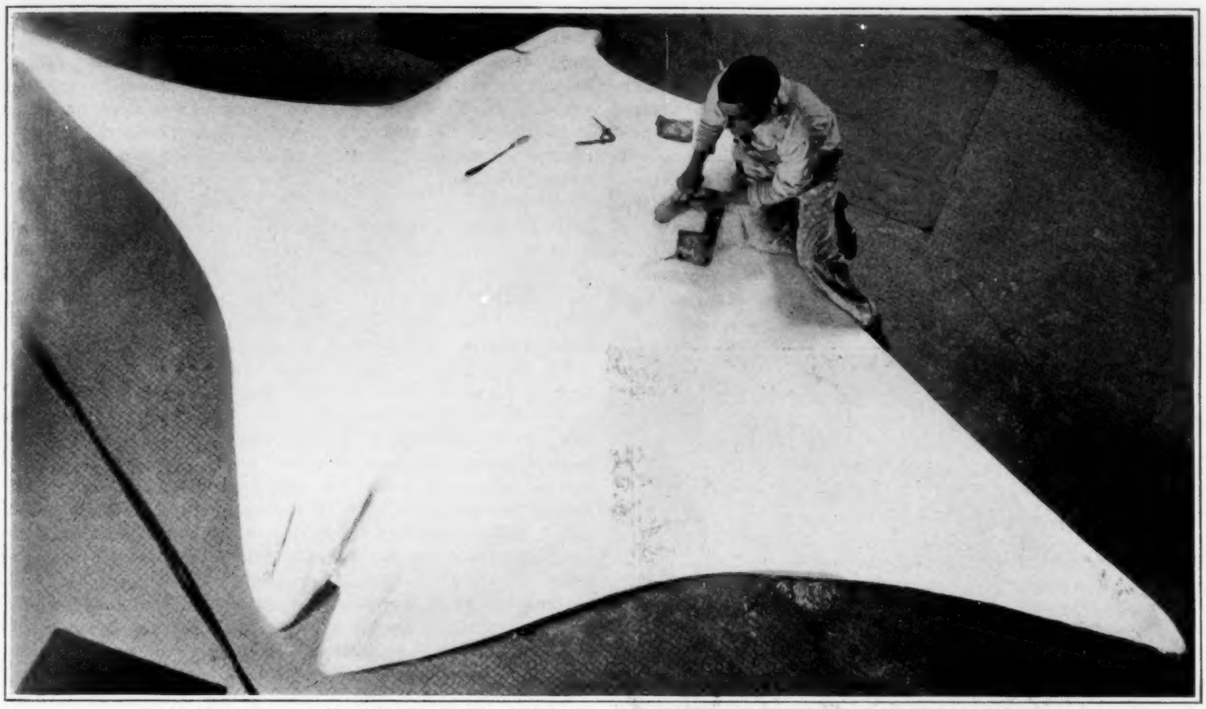
Still other proofs may be offered as revealing the specificity of sanguine plasmas—proofs derived from the transfusion of the blood and from animal grafts as shown in experiments by Christiani Nageotte, L. Loeb, and Krawamura; but to follow these would carry us too far.

CONCLUSION

The facts set forth above constitute biological and chemical proofs in support of the idea that individual differences exist between the proteins of the blood plasmas of various animals, and it cannot be doubted that the albumens of the plasma must be regarded as among the carriers of specificity and individuality. The facts cited furnish as yet only general indications, but it is allowable to suppose that a more intimate chemical study will reveal affinities and differences which inèvitably escape the students of morphology; and it is fair to suppose that methods of chemical research which extend even to the molecules of which protoplasms are composed will lend assistance to the solution of the enigma of specificity and individuality.

THE TERCENTENARY OF THE POTATO

IN 1621 the governor of the Bermudas sent to the governor of Virginia, two large cedar chests in which were plants and fruits and vegetables, known to the coral islands, but not to the mainland. This event will be celebrated next December, for the potato was one of the best contributions.



REPRODUCING AN ENORMOUS DEVIL FISH AT THE AMERICAN MUSEUM OF NATURAL HISTORY

The Monster Devil Fish

Curious Habits of the Manta—A Gigantic and Powerful Marine Ray

By May Tevis

HIS Satanic Majesty has given his name to no less than five denizens of the deep sea—all of them as might be supposed from the title "devil fish," creatures of peculiarly fearsome or repulsive aspect. Best known of these, of course, is the giant octopus, whose evil looking head and writhing snake-like arms or tentacles suggest the ancient Greek fable of the snaky-locked Medusa. Other animals to which the term devil fish is applied are the Victorian *Lacepedia charpactra*, the gray whale, the angler, that huge and misshapen creature from whose body extend long filaments by means of which it is supposed to attract its prey, and from which it derives its name, and finally, the great ray sometimes as much as 20 feet broad and 12 feet long, which is the subject of the present article.

As our pictures show the manta is extremely broad and flat, somewhat suggesting a bat with outspread wings. The name manta is derived from a Spanish word meaning blanket while the alternative name devil fish refers to the two cephalic fins, which the creature has the power of rolling up so that they forcibly suggest a pair of short, straight horns like those often pictured as extending from the head of Beelzebub.

Because of peculiar bat-like shape, the manta and its relative the mobula, are sometimes known as sea bats or vampires. C. F. Holder lays special emphasis on the bat-like aspect of these fish, a similarity increased by the fact that the pectoral fins are long and wing-like, and are, indeed, used with a wing-like motion. Holder writes: "In following one another around the circle they raise the outer tip of the long wing-like fin, high out of the water in a graceful curve, the other being deeply submerged. . . . Now gliding down with flying motion of the wings; sweeping, gyrating upward with a twisting vertical motion, marvelous in its perfect grace; now they flash white, again black, so that one would say they were rolling over and over, turning somersaults were it possible for so large a fish to accomplish the feat."

Other observers confirm this statement, averring, indeed, that the fish actually does turn somersaults. The likeness of the motion to flight is increased by the frequent leaping of the fish above the surface of the water. While many persons have declared their belief that the fish actually entirely leaves the water, a recent writer upon this subject, Russell J. Coles, declares this to be a mistake, careful observation having convinced him that only the forward portion of the body emerges from the water. In leaping the manta makes a headlong rush till about half its body is above water, and at the same time it revolves rapidly turning like a wheel on its axle. One pectoral fin disappears under water while the other rises straight up in the air describing the arc of a circle. During this revolution the tail (in the adults) stands rigidly out from the body. A related species, the *mobula olfersi* (also known as a devil fish) leaps entirely clear of the water, sometimes to a height of more than 5 feet in the air, slapping the water with a loud thump when it returns to it.

The Fins.—While devil fishes are relatives of sharks and every gradation of form is to be found between the long narrow bodies of sharks and the broad bat-like bodies of these great rays, the latter use their fins in a very different manner from the former. As we have said, the pectoral fins have a sweep like that of the wings of a bird or bat. But the head fins or cephalic fins are still more highly differentiated; they are, in fact, grasping organs and have a power of rolling upon themselves which has been compared to the curving of an elephant's trunk. These fins are also called arms, feelers, claspers, caropteres and horns. When swimming the fish

plies these very muscular and powerful "arms" with great rapidity in front of its mouth. Since they have an inward motion this action tends to bring food toward the mouth, just as a greedy, small boy might spread his hands apart on a table covered with candy to rake it toward himself. Well authenticated stories are told of cases in which a huge manta has seized the anchor of a boat with these powerful claspers and rushed violently off with it. It seems probable, however, that such an action was not malice prepense on the part of the animal, but resulted from the fact that the natural clasping propensity of the fin caused it to operate automatically upon coming in contact with the anchor. Upon feeling the tug of the line, however, the fish sometimes turns to attack the boat.

VENTRAL VIEW OF THE GIGANTIC DEVIL FISH

The Food.—It was formerly supposed that these animals fed on large fish and there was even an ancient superstition that they sometimes attacked and ate men, covering the body of a swimmer as with a blanket, whence the Spanish name of *manta* As a matter of fact, however, they live chiefly upon shrimps and other crustaceans or on shell fish and such small organisms. In the Gulf of Mexico they are accused of doing considerable damage to oyster beds. It is probably because of the character of their food that their mouths are provided with peculiar organs not found in any other fish and termed prebranchial appendages. These consist of elongated lamallæ somewhat resembling ferns in shape and arrangement but with the leaflets turned back toward the gills. Each of these lamallæ consists of a fold of mucous membrane supported by a cartilage and they are attached to the anterior surface of the branchial arches in front of the organs of respiration. They are not, however, used for breathing, but are supposed to be employed as strainers like the gill-rakers found in the giant sharks, retaining the small animals taken into the mouth while allowing the water to escape. The jaws are supplied with bands of teeth, as shown in our engraving.

REPRODUCTION

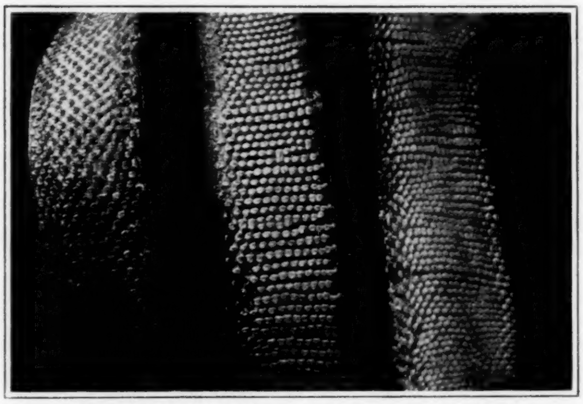
Nothing is more singular, perhaps, in the habits of the devil fish than the method of reproduction. The sexes mate like mammals and live in couples, and the young are born alive like those of mammals, only one being produced at a birth. Strangest of all is the fact that the female produces a nutritious secretion not unlike milk. The mucous membrane of the oviduct is shaggy from the vascular filaments ranged upon it. These contain a milk-like fluid and when examined under the microscope each filament is found to be provided with superficial muscles which, when contracted, serve to squeeze the milk out—a highly convenient self-milking apparatus! Since the embryo has no power of sucking the "milk" out for itself, some such mechanism is necessary. When the young one is examined the mother's milk is found inside the modified first pair of gill-clefts or *spiracles* and also in the intestine. Ichthyologists therefore consider it quite proper to say, in a manner of speaking, that the unborn young fish actually drinks its mother's milk although it does not take it in through the mouth, but, according to Theodore Gill, "by channels homologous with the ear-drum of air breathing vertebrates" (quoting an English authority on the subject, Mr. A. Alcock).

In its early stages the young embryo is nourished from the yolk in the egg sac, just as a young chick is within its shell. The above secretion known as *uterine milk*, is not developed and absorbed until the later stages of the process of gestation. While this "milk" serves the purpose of nutrition, it is chemically different from that of mammals.

The development of the young embryo is undoubtedly like that of all other rays and has therefore some peculiar features. It is very different in shape at first from the parent fish, having instead a form much like that of a shark, its remote ancestor. It has, however, breast fins provided with basilar extensions which are free from the head and which extend forward parallel with the head in front of the eyes. Later, these extensions unite with the sides of the head, thus producing the form of the adult before it leaves the mother's body.

Many observers have noted the very striking and curious fact that when a pregnant fish is attacked the offspring is forcibly thrown out. Russell J. Coles, who captured the magnificent specimen from which our photographs are taken, and which we owe to the courtesy of the Museum of Natural History, gives the following graphic account of such a proceeding. The animal in question was a female 18 ft. 2 in. in breadth and about two thirds as long.) Mr. Cole writes in his *Notes on the Devil Fish*, published in 1916, in the Bulletin of the American Museum of Natural History:

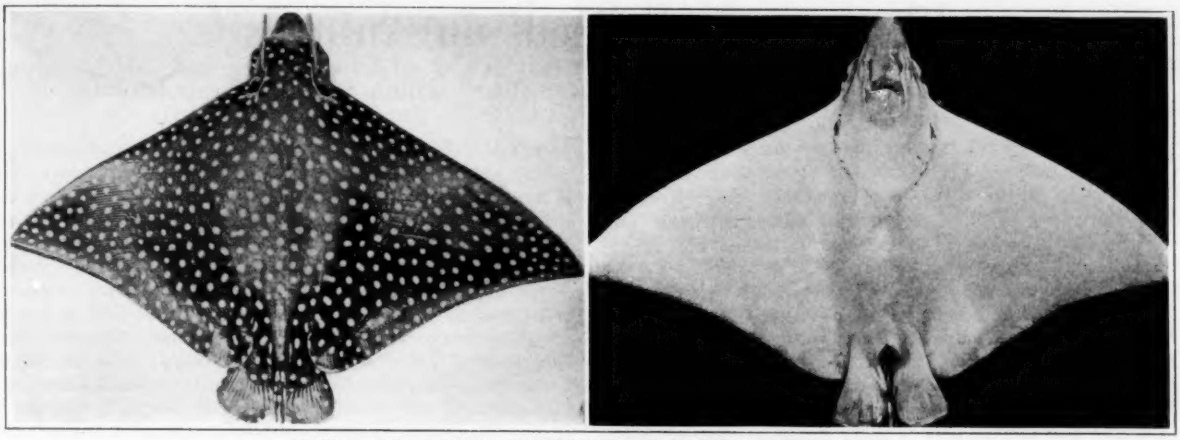
"Almost immediately after being struck by the harpoon the manta made a sidewise revolution along side the boat, and just before the tail had reached the perpendicular an embryo was violently ejected to a distance of about four feet. The



BANDS OF TEETH ON THE JAW OF THE MANTA

embryo appeared tail first, folded in cylindrical form, but it instantly unfolded and its pectorals moving in bird manner retarded its descent until the mother fish had disappeared beneath the surface. I was almost in the act of securing this embryo when it was swept below by a pectoral of the large male mate, which was near the big female. This embryo was well advanced with a width of more than three feet and a tail approximating eight feet in length. An examination . . . showed that the embryo had been contained in the left uterus and the uterine filaments were richly charged with the thick creamy substance absorbed by the spiracles."

The writer has been unable to find out whether this forcible sort of "parturition" or pseudo-parturition is due to an in-



DORSAL AND VENTRAL VIEWS OF ONE OF THE SPOTTED RAYS

stinctive desire of the animal to save its offspring when threatened, or merely, to the convulsions produced by its dying agonies. Apparently, however, it occurs only when the embryo is almost ready for independent life.

While the most recent name for this family of fishes is *Mantidae* (the term employed by Jordan and Evermann) some older authorities prefer the term *Mobulidae*.

The Sounds Produced.—While all devil fishes are characterized by the sounds they produce, there is some difference expressed among naturalists as to the nature of these. Holder speaks of the rushing, swishing thunderous sound produced by the *manta-birostris*, whereas Coles found the startling loudness of the sound somewhat exaggerated. The latter says with regard to the different sounds made when dying, "The dying *mobula* occasionally makes a musical bell-like sound; but three of five dying manta emitted a harsh, bear-like cough." These sounds, of course, must not be confused with the noise made by these fish during their leaping and rushing progress through the water.

The manta belongs to the extensive group of fishes known as the *Raiidæ* which includes the skates and the rays. The great majority of the species in this family belong to the genus *Raia* which lives chiefly in temperate seas, but is more abundant in the northern hemisphere than in the southern, but which approaches the Arctic and Antarctic regions. The top of the body in fishes of this genus is similar in color to the sandy or gravelly bottom where they are in the habit of living, and this camouflage serves to conceal them from the small fishes, crustaceans and other creatures upon which they prey; as the ray is a rather slow and sluggish fish, this concealment is very useful in luring their victims within their reach. Since the mouth is on the under side of the body the ray cannot seize its food as soon as it comes within reach, but is obliged to dart out above it, in which position it can readily devour it. Most of the species have some value as food fishes. The sexes are usually differentiated, not only in size and in color, but in the character of the teeth and also in the presence and arrangement of rows of specially modified spines on the skin of the back.

GASEOUS EXCHANGES BETWEEN PLANT ROOTS AND THE AIR

AT the session of the French Academy of Sciences held December 20, 1920, the plant physiologist, M. Raoul Cerighelli, made known the result of his experiments concerning the *relation between the roots of plants and the aerial parts of the same plant*, and also concerning *roots which had been previously detached*. The roots examined were those of plants growing in their natural location or else in cultivated ground, or were taken from plants growing in pumice stone saturated with Knops' liquid. In those cases in which the roots were allowed to adhere to the plant, two series of experiments were made. In the first series the organs examined were luted in the vicinity of the collar (the junction of root and stem) to culture vessels made of inverted lamp chimneys; in consequence of this arrangement their gaseous exchanges took place in the moist pumice stone. In the second series of experiments the organs were also luted to the culture vessel but after the latter had been emptied of pumice stone; the roots, therefore, functioned in a slightly humid atmosphere of air.

In the case of roots previously detached from the air-growing portions of the plant, the same arrangements were made, the roots being likewise placed either in air or in pumice stone saturated with a nutritious liquid. The temperature was kept constant by means of a thermostat, the gas was analyzed by the "method of confined air." Finally, the roots were placed in the dark and allowed to remain for varying periods of time; in the case of adherent roots this period was in some cases as much as 24 to 48 hours. Among the plants studied were the *Senecio vulgaris* L., the *Lupinus albus* L., the *Laurus nobilis* L., the *Sonchus tenerrimus* L., the *Erodium malacoides* Wild, the *Heliotropium europaeum* L., etc. Without going into the details of the various experiments, we may give the results as follows:

1. The respiration of roots takes place like that of the other organs of the plant when placed in a confined atmosphere. There is an absorption of oxygen and a liberation of carbon dioxide in quantities such that the ratio $CO_2 : O$ has a value which varies from 0.7 to 1 according to the species.

2. When the roots are in contact with a very humid atmosphere there is an increase in the respiration: the quantity of oxygen absorbed and the quantity of carbon dioxide exhaled are both greater than in a dry atmosphere, and the ratio $CO_2 : O$ remains constant (in the case of the cut-off roots in the pumice stone).

3. When the roots are in contact with a very humid atmosphere and *are still connected with the aerial parts* there is likewise an augmentation of the respiration, but the carbon dioxide formed during this function is not completely exhaled, and a portion of this gas is drawn upward into the upper portion of the plant, so that the respiratory ratio attains only very low values in these cases. This phenomenon appears to be connected with the absorption of water by the root, since it is the water absorbed which carries with it the carbon dioxide.

The investigator remarks finally that in no case did he discover any absorption of carbon dioxide, at any rate in the gaseous state. He believes, furthermore, that the carbon dioxide having its origin in the roots probably plays a more important part in the plant than the carbon dioxide which is dissolved in the water of the ground and which is absorbed with this water.

A Plant That Feeds on Animals

Bladder-Shaped Structures of the "Water Pipe" which Serve to Trap Insects

MOST of the so-called carnivorous plants, namely, those that trap insects and make use of their juices for their nutriment, are of tropical origin. However, there are a few such as the sun-dew which have the same habit though they belong to temperate zones. One of the most interesting of these is the little water plant *Utricularia vulgaris*, commonly known as the water pipe. This is interestingly described and pictured in a recent number of *Kosmos*.

Upon the delicately divided leaves of the *Utricularia* there are numerous bladder-like structures filled with water which appear to offer a very tempting retreat for the tiny living creatures of the pond where the plant grows, but woe to the water flea or rotiver who seeks refuge in one of these; for these little vesicles are, as a matter of fact, open pitfalls with a devilishly clever device, a sort of hedge of bristles to keep their victims from getting out when they have once fallen in; they are kept captive like mice in a trap. These curious bladder-shaped structures were long thought to be swimming bladders, and there was no suspicion of the fact that they are really animal traps. As shown in our picture (Fig. 1) they are round or oval in shape and provided with a short stem. They are about 49 mm. in diameter. Close examination shows them to be surrounded by a many celled wall (Fig. 3). The mouth is quite singularly formed; the lower lip (*u*) is thick and club-like in shape and furnished with short hairs, whose glands apparently furnish a secretion which serves to attract its victims. The upper lip (*o*) is opposite the lower lip and shuts like a flap (*v*) or valve in the interior of the tube. The entire orifice of the mouth is surrounded by a very forest of appendages or antennæ (*t*), which taken together much resemble a sort of fish weir and probably act in the same manner.

As soon as a water flea reaches the entrance of this little "weir" he is at once conducted to the entrance of the bladder. When he reaches this his slightest motion opens the valve so that he passes straight as a die into the desired hiding place. But once in the elastic door slams shut and since it cannot be opened from the inside the water flea finds himself unable to escape. Moreover his captivity soon begins to be highly uncomfortable, since upon the inner wall of the trap are certain small glands giving forth a sticky fluid, and these open as suddenly as the faucets of a bath tub turned on by an invisible hand and empty their contents into the vesicle. Sooner or later the captive animal is miserably drowned and begins to putrefy. In this latter condition he is just ripe for the table of his host. By means of the short hairs which thickly cover the entire inner surface of the tube the vesicle absorbs the juices set free by the decomposition of the corpse and makes use of them for the nutrition of the plant.

It is really quite astonishing what a large number of animals the plant is able to devour in this ultra-refined manner. Büsgen observed that a moderately large plant in the course of 1½ days captured twelve water fleas with a single vesicle.

The water flea is not the only victim either; the plant also traps grasshoppers, mussel-crabs, rotifers, infusoria and other one-celled animals, plant lice, small worms, and even small tadpoles.

The plant nourishes itself in this manner until early summer; by this time it is in such a well fed condition that it is ready to bloom. It now undergoes a very marked alteration. Up to this time it has had the form of from 8 to 12 meager whorls of leaves unprovided with either roots or stems and blown about by the wind in the upper layers of ponds and ditches. But now it often sends up a leafless green stem as much as 12 cm. above the surface of the pond, with a loose cluster of blossoms at the top (Fig. 2). The small flowers are of a gorgeous lemon color adorned with all sorts of bright spots and streaks. After the petals fall the flower head goes back more or less completely under the water. The flowers are fertilized by insects and bear only a few seeds, so that the reproduction and distribution of the plants is chiefly accomplished by the small winter buds which vary in size from that of the head of a pin to that of a pea, which are formed in the late summer upon various parts of the feathery looking leaves. At the end of the vegetation period these buds drop from the plant and are carried far and wide by the currents of the water. They spend the winter in the mud at the bottom but rise again to the surface in the spring and develop into new plants.

THE RIPENING AND STORAGE OF BARTLETT PEARS

A DISTINCT relationship has been found between the total amount of sugar present in the ripe pear and the temperature of storage at which it had been held from the time of removing from the tree, until ripe. Pears ripened at 70° F. contained the highest percentage of sugar, at 40° the lowest, and those held at 30° from 6 to 14 weeks and then ripened at room temperature were intermediate in amount of total sugar. There was no marked relation between temperature of storage and relative amount of sucrose and reducing sugars. There is a marked and uniform increase in total sugar in the pear from summer until after the time of the close of the picking season.—Abstracted from *Jour. Agr. Research* 19, 473-500 (1920) by *Chemical Abstracts*.

FIG. 1. THE LITTLE VESICLES (bl) WHICH SERVE AS TRAPS FOR INSECTS

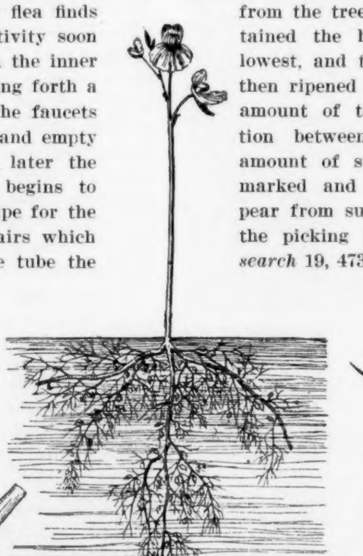


FIG. 2. THE *UTICULARIA VULGARIS* OR WATER PIPE IN BLOOM

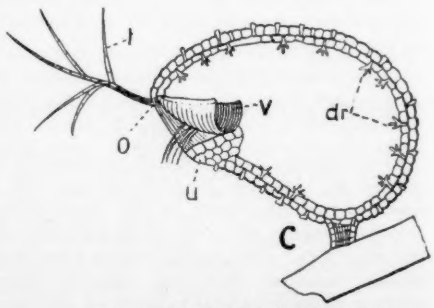


FIG. 3. SECTIONAL VIEW OF ONE OF THE BLADDER-SHAPED VESICLES

Microscopy with Ultra-Violet Light*

Increased Resolution Obtained by Using the Short-Wave Light Beyond the Visible Spectrum

By J. E. Barnard

THE microscope is now so widely used in all branches of science and in industry that it is not surprising to find an increasing demand for greater optical efficiency. It must be admitted that in comparatively few cases is the instrument used under such conditions as to secure the best possible result; but this is due to lack of appreciation of the principles involved, and will be remedied only by a wide educational effort. Even when the greatest optical efficiency is secured, the limitations are soon felt. The chief need is for increased resolution, that factor on which the delineation of minute structure depends. Advances of great value have been made in methods of rendering visible minute objects, but it must be clearly realized that, while this greater visibility can be secured, no information as to the form or structure of objects which are below the resolution limits is to be obtained by this means. Increased magnification is by some workers still regarded as desirable, but unless this is accompanied by proportionally increased resolution, the results are worse than useless, and can lead only to serious errors of interpretation.

Two factors mainly govern resolution—namely, the numerical aperture of the objective, and the mean wave-length of the illuminant. No increase of numerical aperture has been obtained since the classic researches of Abbe, resulting in the production of apochromatic objectives; and in the present state of knowledge there appears little likelihood of any substantial advance in this direction. By using light of short wave-length, a promising field of research is at once opened up. An increase of resolution is obtained even with visible light if the violet or blue end of the spectrum is utilized, but the increase is much more definite if ultra-violet light is used, although the image is no longer a visual one.

The computation of microscopic objectives for use with ultra-violet light presents considerable difficulties, as only two substances sufficiently transparent to these radiations are available—quartz and fluorite. So long ago as 1860 Spencer in America used fluorite for this purpose, and at a much later date Boys in this country suggested the possibility of using fused quartz. In 1904 Kohler, of Jena, succeeded in computing objectives entirely of fused quartz, some earlier ones which were fluorite-quartz combinations being thereby superseded. Ultra-violet light, therefore, became available for microscopic work, but the practical difficulties in the use of the apparatus are so considerable, calling for almost more knowledge of physical than of microscopical methods, that it has been used by few.

The results obtained, particularly in biological work, are in many cases of great interest, as, in addition to the advantages already indicated, there is the further important point that organisms are dealt with and photographs obtained of them in the living state. The classic researches of Hartley showed that organic substances which are perfectly transparent to ordinary light have very definite absorption regions or bands in the ultra-violet, and that their absorption is, in many instances, so characteristic that it constitutes an accurate method of identification. To a considerable extent, this fact is of value when using ultra-violet in microscopy. Objects that show little or no structure by transmitted light are seen to be highly organized when examined by ultra-violet radiations, and the structure seen is in part dependent on the wave-length of the light used. Objects for examination by this method must be dealt with in the living state, or at least in such a manner that no change takes place in their constitution. It follows that none of the ordinary methods of mounting such things as micro-organisms, in which staining, hardening, fixing, drying, or heating is resorted to, can be employed. The method is, in fact, its own staining process, differentiation of structure depending on the difference of absorption in ultra-violet, and not on complex staining processes, which are in some cases causing appearances not associated with the organism itself. Further, apart from the alteration that may take place in the tissues themselves as the result of such processes, their employment in the method under consideration would render them opaque to the radiations used, and, therefore, useless for the purpose. The organisms or tissues are simply mounted in any suitable fluid, such as water, normal saline, Ringer's solution, etc., which is transparent to ultra-violet light and the photograph is taken at once. The result is an image that, whether it shows more or less than a stained preparation, is a representation of the object in the living state, and with greater resolution than can be obtained in the microscope by any other process.

Such a method is obviously one to be tried to its utmost whatever practical difficulties may be involved, and there is little doubt that in time it will be recognized as what it really is—the only great advance in microscopic technique for a generation. The apparatus as used by the present writer is in its essentials the same as that devised by Dr. Kohler (Fig. 1), although in many points of detail improvements have been devised. The quartz objectives are three in number, their equivalent focal lengths being 6 mm., 2.5 mm., and 1.7 mm., their effective numerical aperture being respectively 2.50, 1.7, and 0.7. It will at once be appreciated that in cases where the full aperture can be utilized the two higher powers are of much greater N.A. when used with light of 275 $\mu\mu$ wave-length than any objective available for use with ordinary light. These two are glycerine immersion combinations, the refractive index of the immersion fluid being 1.447.

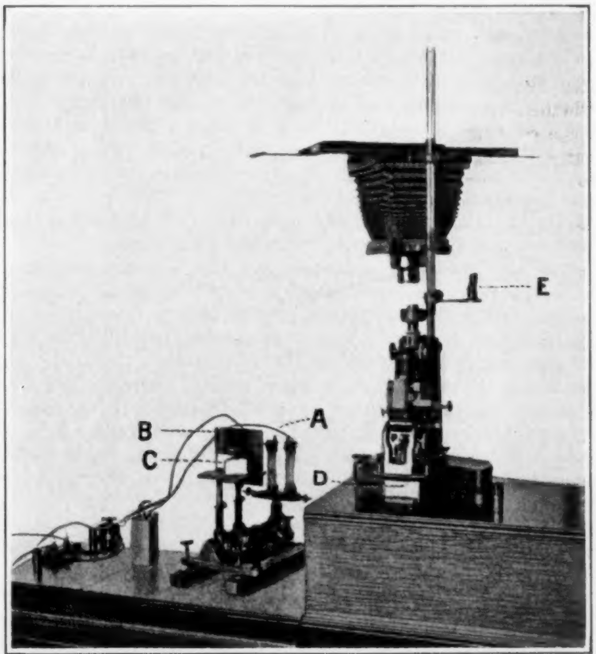
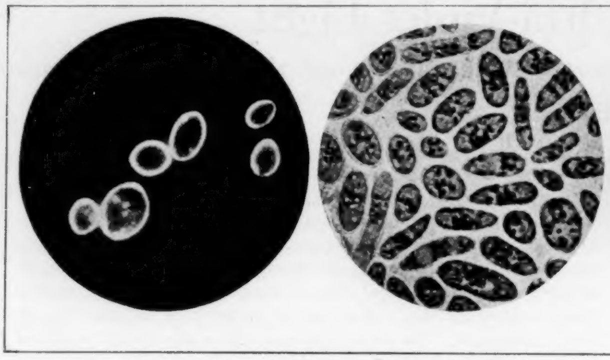


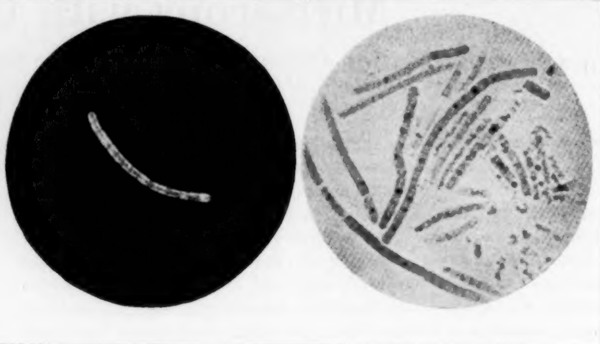
FIG. 1. APPARATUS FOR TAKING PHOTOMICROGRAPHS WITH ULTRA-VIOLET LIGHT

A, spark gap; B, quartz condensing lens; C, quartz prisms; D, box containing reflecting quartz prism; E, fluorescent ocular. The position of the other parts described will be evident to any microscopist

*Reproduced from *Nature* (London), Nov. 18, 1920.



FIGS. 2 AND 3. SACCHAROMYCES PASTORIANUS (YEAST) ×1200
Left dark ground illumination; *right*, ultra-violet light



FIGS. 4 AND 5. BACILLUS ANTHRACIS ×1000
Left, dark ground illumination; *right*, ultra-violet light

As these systems are not homogeneous, the cover glasses are optically worked fused quartz of uniform thickness.

The slides are also of fused quartz, fitted into a carrier of a special type, which ensures that the surface of the slide is a constant distance from the objective, a point that in practice is of considerable importance. The quartz oculars are five in number, and range from an initial magnification of 5 to 20, giving camera magnifications of from 200 to 3,600 diameters. The latter is a good deal too high for satisfactory results with most objects—in fact, it is doubtful, on theoretical grounds, whether such a magnification is justified. The quartz sub-stage condenser is made with a duplex top, so that a combination is available for each objective to ensure that a suitable cone of illumination is used in each case. This is used as a glycerine immersion system with the two high-power objectives, and as a dry system with the lowest one.

The source of light is produced by a high-tension discharge in air between metal electrodes, usually cadmium or magnesium, although other metals may be used if they produce a suitable line spectrum. There are obvious limitations in this respect, as the character of the spectrum emitted must be such that the principal lines in the ultra-violet region are sufficiently separated and of considerable intrinsic brilliancy. The spectrum of iron, for instance, is excluded, as, although it is rich in bright lines, these are so numerous and therefore so close together that the isolation of one line is impossible under the conditions realized in this method.

The spark is produced by means of an induction coil of special design giving a heavy discharge of relatively low potential, the equivalent sparkgap being about 5 cm. This is further reduced by placing a condenser immersed in oil in parallel with the spark-gap. The interrupter may be either an electrolytic one or a mercury break, the latter appearing to be more satisfactory. Special arrangements are made for accurately adjusting both the length of the spark and its position in relation to the optic axis of the microscope. The image of the spark is projected by means of a quartz lens, so that, after passing through a pair of quartz prisms of opposite rotation, an image of the spark in one wave-length is obtained approximately at the position of the iris diaphragm below the sub-stage condenser. To facilitate adjustment, a disk of uranium glass is placed at the latter position so that an image of the spark can be observed and focused as required, after which the uranium glass in its carrier is swung aside. The direction of the illuminating beam is at right angles to the optic axis of the microscope; it has, therefore, to be reflected by a right-angled quartz prism along the axis in the same way that the mirror operates in an ordinary microscope.

The preparation being placed on the stage, the light adjusted, and the condenser accurately focussed on the object, the actual focussing of the image has to be carried out. This is effected by means of a fluorescent searcher eye-piece which is mounted above the quartz ocular, and by the use of which an image is seen on a fluorescent screen and focussed by means of an auxiliary magnifier. This operation is one of considerable difficulty, and only after long practice can success be assured. Its difficulty varies, too, according to the wave-length used; in some cases the fluorescent image is bright, but in others it is much more difficult to see. Some objects themselves fluoresce, with the result that a sharp visual image cannot be obtained. The method now largely adopted by the writer is to observe the object by monochromatic light as emitted by a quartz mercury vapor lamp. This illuminant has bright lines in the violet, blue, green, and orange regions, and by means of screens any one of these can be transmitted.

The image having been focussed visually in one of these lines, the fine adjustment of the microscope is moved by a predetermined amount so that the image is in focus for any desired wave-length in the ultra-violet. This method is quite practicable provided that the fine adjustment of the microscope is of sufficient accuracy (the searcher eye-piece is not used in this case except to confirm the accuracy of the process). The focussing having been performed, the searcher eye-piece is removed, the camera placed in position, and the exposure made. The image is projected for a certain distance, so that it is in focus at the plane of the plate with a known length of camera. The exposures required are as short as two seconds under favorable conditions, even at high magnifications.

There was considerable difficulty in obtaining a suitable photographic plate, as one was required of fine grain and with the smallest possible quantity of gelatine on its surface. Gelatine is itself opaque to ultra-violet light, so that the photographic action is confined to the surface of the gelatine, little or no penetration in depth taking place as with ordinary light. The result is that plates must be prepared with the smallest possible quantity of gelatine, but with the maximum quantity of sensitive silver salts that the gelatine can hold together. Such a plate has been prepared by the Kodak Co., and has proved satisfactory. Plates as prepared by Schumann for work in the far ultra-violet have also been experimented with, but for various reasons have not proved so satisfactory. The resulting negatives are at first glance somewhat disappointing if judged by ordinary photographic standards. They are always thin and lacking in violent contrasts, owing to the superficial action of the light, but the detail and fineness of lines due to the shorter wave-lengths used are evident to anyone having any knowledge of photomicrography. Whether the utmost resolution that theory demands can be achieved is at present unproved because of the difficulty of finding an object that can be regarded as a satisfactory test.

The accompanying illustrations give some idea of the comparative results obtained with living organisms. Figs. 2 and 4 are illuminated by a concentric dark-ground illuminator, the most satisfactory method available for observing living organisms by ordinary light, and Figs. 3 and 5 by a solid cone of ultra-violet light.

Artificial Cells*

Remarkable Imitation of Natural Cells

By A. L. Herrera
Director of the Bureau of Biological Research of Mexico

It is a well-known fact that numerous attempts have been made to reproduce the structure of the natural cell, especially by Bütschli, Traude, Lebuc, and Herrera. Professor Herrera gives here the results of his latest researches, which have been remarkably successful, along these lines.

It must be borne in mind, of course, that the structures of natural cells obtained by treatment according to the classic histological methods, can hardly be said to correspond closely with the aspect of the same cells while living. When the endeavor has been made to indicate the structure of natural cells by means of precipitates from various solutions, the investigator has too often taken as his model the histological aspect, and not the living appearance of the cell in question. Because of this, considerable caution must be maintained in drawing definite conclusions from such experiments.—Preliminary note by the Editor of *La Nature.*

THE admirable researches made by Gautier and Clausmann with respect to the biological importance and the general occurrence of fluorine in organic creatures are now well known, as are also the studies made by Schultz and Boudard concerning the presence of silica in organic tissues together with the physiological rôle and therapeutic application thereof. These two elements have been unjustly neglected for a great many years, but modern research has shed light upon their importance in the phenomena of life. One fact of especial significance is prominent through the researches with regard to plasmodeny, which I have been conducting since 1897, and which have led me to devote special attention to the fluoro-silicate. This fact is that the imitations of cells and tissues obtained by means of the silico-carbonate of calcium although possessing a great morphological resemblance to natural elements are attacked and dissolved by the histological fixators, all of which are acid—a circumstance which sets them greatly apart from living models. Nevertheless, I have sought to discover artificial structures capable of presenting a like degree of resistance to acid. An earlier observation incited me to study the remarkable imitation produced upon glass by the vapors of hydro-fluoric acid—structures which reproduce those of micro-organisms found in stagnant water, but which are much harder than the latter and which exhibit much difficulty in acquiring histological coloration.

In my first experiment I repeated the technique employed by Harting (vide C.R. *de l'Acad. d. Sc.*, May 19, 1919). In an 18 cm. crystallizing dish I placed some colloidal silica having a density of 1,030 together with two soluble salts, calcium chloride and potassium fluoride. Through slow diffusion and incomplete crystallization I secured the formation of really remarkable imitations of amoeba and of organic cells. Finally, by means of a gradual improvement in the conditions of diffusion I succeeded in producing truly wonderful facsimiles of histological elements. The specific technique employed consisted in compressing between sheets of glass two solutions, one of potassium silicate having a density of 1,100 and containing traces of potassium bifluoride and the other of calcium fluoride with a density of 1,320. The solution of the silicate should contain as small a quantity of potash as possible; it is prepared by dissolving freshly prepared gelatinous silica in 750 cubic centimeters of water to which have been added 10 drachms of caustic potash. As high a temperature as possible is then applied in a vulcanizer.

In the last experiment a drop of silicate was compressed beneath a sheet of glass by means of a weight of 22 kg., while the drop of calcium chloride was compressed by a weight of 5 kg. beneath the contiguous sheets. The sheets of glass are then covered with a bell glass under which are introduced moistened cloths; the edge of the bell-glass is smeared with plaster of paris in order to prevent the drying of the solution. The object of the compression is to retard the diffusion of the liquid, thus imitating those infiltrations which produce agates. Twenty-four hours later they are washed and examined under the microscope then fixed, colored, and mounted in balsam as is done in the case of ordinary sections of tissues. Care must be taken to employ Kuhne's blue and mordants, since the structures are still too hard and too slightly permeable.

The waves of diffusion produce periodical precipitates and the exhaustion of the calcium chloride solution occasions the gradual transformation of the waves into smaller and smaller segments, which reproduce the form and structures of cells with surprising fidelity, as can be seen by the accompanying sketches and microphotographs.

In preparation 3,804, of May 17, 1920, there was observed a complete colony of cells having a membrane, a spongy cytoplasm, or spongioplasm, a nucleary membrane, a nucleus, a nucleole and chromatic filaments. The pseudo-cells earlier observed by Traube, Leduc, myself, and others, are far inferior to these truly magnificent elements in which the enormous nucleus, when highly magnified, shows the finely granulated aspect of the nucleus found in true cells as well as other well-known details.

And an even more striking feature is the tendency to division exhibited by all these cells, as can readily be seen at certain points in the reproduction of this same preparation, as well as in others prepared for the Academy of Sciences.

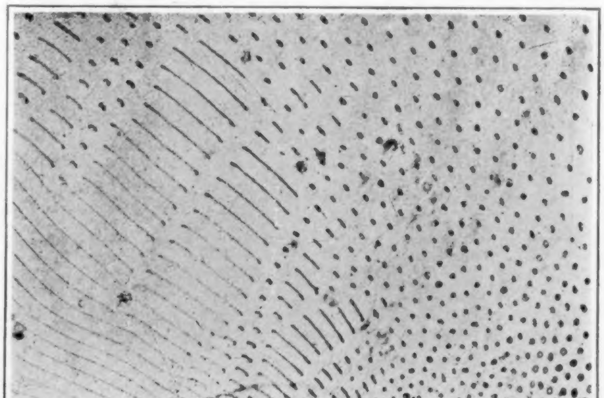


FIG. 1. MICROPHOTOGRAPH OF A PREPARATION MADE BY PROFESSOR HERRERA

The mitosic figures are still vague and incomplete, but two stars (asters adossi) backed up against each other in the poles of the ovoids and the filaments between them can readily be distinguished. Asters are often found in the points of an elongated granular tube. By compressing the

*Translated for the *Scientific American Monthly* from *La Nature* (Paris), July 31, 1920.

sheets of glass under a pressure of 60 kg. I succeeded in obtaining colonies of cells undergoing the process of division, taking the blue stain and revealing all the passages between the cells with the nucleus and the protoplasm in a state of repose, as well as those showing the division of the nucleus without the division of the protoplasm, with an ulterior division of the latter and the complete separation of the daughter-cells. One of these preparations was sent to the French Academy of Sciences, and the other to Dr. MacDougal of the Desert Laboratory at Tucson, Arizona.

But what explanation can be offered for the occurrence of these results and how shall we interpret them? This question is not very easy to answer and is much less interesting than the facts themselves.

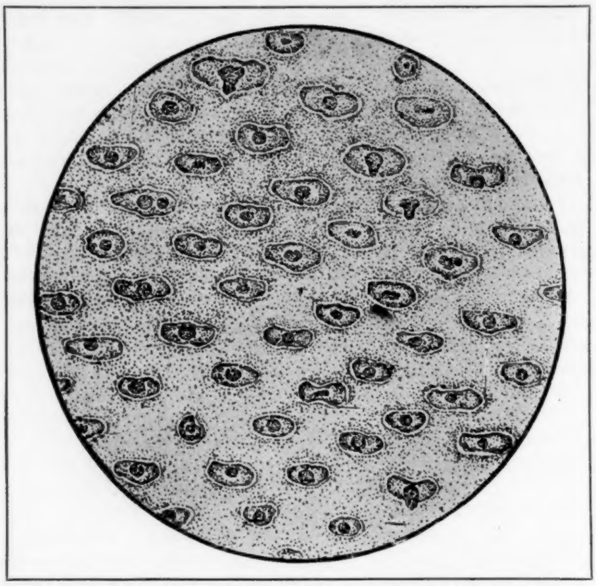


FIG. 2. CELLULAR APPEARANCE OF PREPARATION NO. 3804 OBTAINED BY SUBJECTING POTASSIUM SILICATE AND CALCIUM CHLORIDE TO PRESSURE

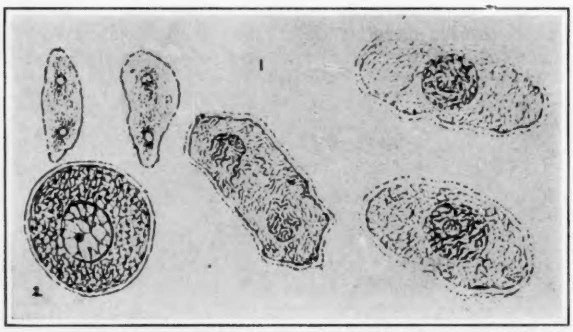


FIG. 3. MAGNIFIED VIEW OF A PORTION OF THE PREPARATION SHOWN ABOVE

At *2* is shown the reticulated structure of a natural cell, after Schäfer, showing, from periphery to center the membrane, protoplasm, nucleus and nucleole

When macroscopic crystals of the double chloride of calcium and potassium are placed in a bath of potassium silicate, it is observed that each crystal encloses a residue of the calcium chloride solution; this produces very fine precipitation, membranes forming a sort of protoplasmic emulsion. It is probable that the same effect is likewise produced in this instance, but upon a microscopic scale and that we obtain a perfect reproduction of the structure of the protoplasm and the nucleus of which Bütschli speaks. The cause of the segmentation, it is to be presumed lies in the osmotic swelling of invisible alveolæ whose saline enchylema must be supposed to have a great affinity for the water of the external milieu. The hardening of the structure is due to a sort of intensive plasmolysis or dehydration which prevents the later development of the cells and which I have sought, by the condition of my experiments, to retard as much as possible.

A hypothesis at once suggests itself as the result of our researches and reflections. I refrain from calling it a certainty to the effect that life itself may have had a similar origin in the form of slow infiltrations of salts in the silica containing fluorides. A large number of organic compounds of fluorine, of silica, and even of fluoro-silicates, are known to us, and it is possible that upon a mineral skeleton natural forces—heat, sunlight, etc.—have produced protobias capable of living by means of antotrophic processes. Whatever may be thought of this theory, however, the fact reported above, of the production of cells, not only complete in all their parts, but actually undergoing division is both entirely new and profoundly interesting.

NEW FACTS ABOUT VITAMINES

MUCH as we have learned in recent years about those all important though minute constituents of our food, the vitamines, the field of research is by no means exhausted and still attracts many investigations. Some recent results of their studies have appeared lately in various places. Among these are those of M. Auguste Lumière, who has been trying to find out whether these bodies are as essential to the lives of plants as to those of men and animals. He comes to the conclusion that this is not the case. He bases his views upon the fact that microbes can be readily cultivated in mediums of strictly mineral composition which exhibit no traces of organic matter. According to another investigator, maize is capable of attaining complete development in a liquid containing 15 simple substances without any organic matter whatever. Lumière made certain experiments of a similar nature with beer yeast, which is particularly rich in vitamines, for which reason it rapidly effects a cure in pigeons suffering from malnutrition. He found that when the yeast was heated to a temperature of 135° C. for one hour, it had lost all its curative virtues, its vitamines seeming to be entirely destroyed. Yet fungi were found to grow readily in a broth made of this dead yeast. Furthermore, he found that it was possible to isolate the vitaminic principles of the yeast and add them to various culture mediums, without apparently improving the species grown in these. He, therefore, finds that plants do not require the presence of vitamines for their development.

Another experimenter whose work is reported in the *Presse Médicale* believes that he has obtained proofs that the disease of rickets which so often afflicts under-nourished children, is really due to a lack of vitamines, particularly of the lipo-soluble vitamine A. By experiments upon dogs he demonstrated that a diet which produces rickets in the animals ceases to do so if foods rich in vitamines be added, among which he mentions especially butter, unskimmed milk, cottonseed oil and cod liver oil. He finds fresh support for his views in the fact that rickets is a very rare disease in the Hebrides, in spite of the many hardships and privations to which the inhabitants of these islands are exposed. The population lives almost entirely upon fish, oatmeal and eggs, being particularly fond of fish livers, which are known to be especially rich in lipo-soluble vitamines.

It is interesting to find that the popular estimation of cod liver oil as a waste repairing food is thus justified and explained by modern research. Apropos of various facts it is worth noting that while butter and cream and cod liver oil are extremely rich in vitamines, ordinary fat is much less so, especially when it is white in color. Lard, for example, contains practically no vitamine, whereas the yellow fat of grass-fed cattle contains a considerable percentage.

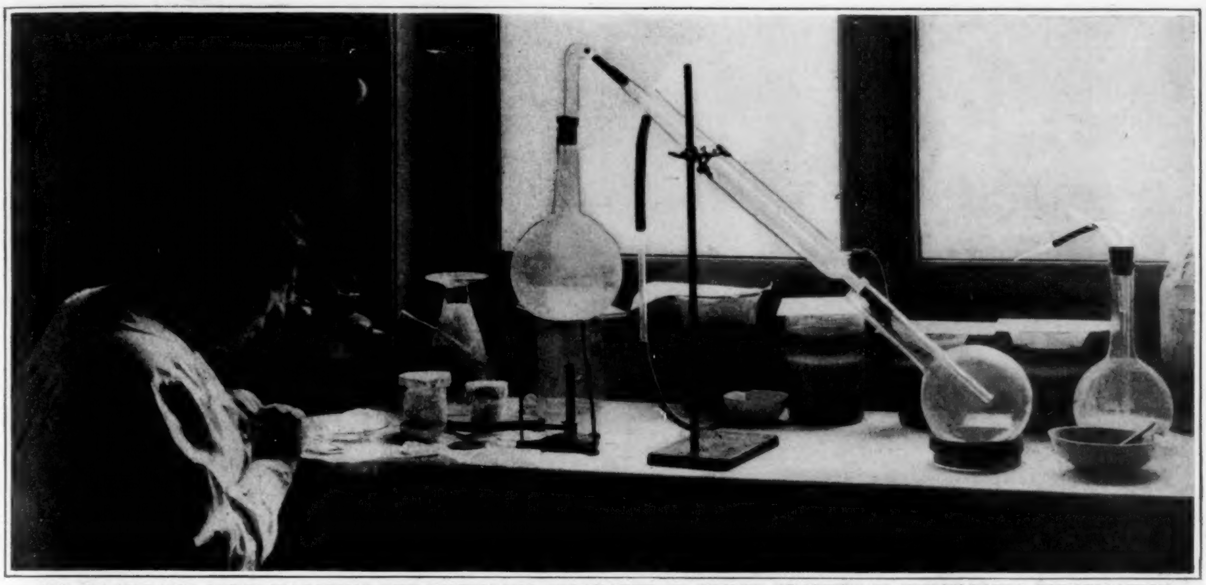


FIG. 1. MADAME CURIE WATCHING THE DISTILLING APPARATUS IN WHICH URANIUM IS UNDERGOING PURIFICATION

The Radium Institute in Paris

The Scientific Equipment of Madame Curie's New Radium Pavilion

By T. A. Marchmay

ALTHOUGH the building which houses it is but a few years old, having been finished at about the time the war was declared, the French Radium Institute now ranks as one of the best equipped in the world, among similar foundations. The work done comprises two branches—the study of the scientific properties and relationships of radium, on the one hand, and its medical applications upon the other. At the head of the former department are Madame Curie and Professor Debierne, while the director of the latter, which forms an annex of the Pasteur Institute, is Dr. Regaud.

The first department is housed in that portion of the building known as the Curie Pavilion and within its walls are carried on by Madame Curie and her assistants those profound experiments which have for their object the widening of the boundaries of our knowledge concerning this most marvelous of elements as well as the practical application of the information we already possess with regard to it. Here, for example, we may see operators at work standardizing the small but infinitely precious radioactive tubes, each of which contains a certain amount of miracle working substance. The method employed in this standardization is known as the piezo-electric quartz method which is described below. These tubes are delivered to physicians and before their dispatch it is necessary that the absolute value of the amount of radium contained in each tube shall be determined. In Fig. 3 the radium tube is seen upon the condenser at the right of the photograph.

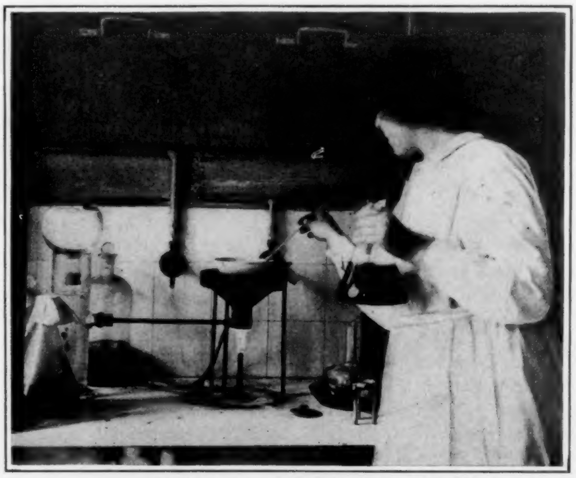


FIG. 2. HEATING A SOLUTION OF URANIUM IN A WATER BATH

When thin lamellæ of quartz or tourmaline are subjected to pressure they develop electricity, known as piezo-electricity. (It. *piezo* = pressure.) This pressure electricity is produced in very minute quantities, yet by means of a very ingenious apparatus which was devised by J. J. Thomson, it has been found possible to employ it to operate a highly sensitive electrometer.

One of the most important of the processes carried out in the chemical laboratory consists of the lengthy series of delicate operations involved in the repeated fractionization and crystallization required in the preparation of the various radio-active salts, *i.e.*, those of radium, polonium, actinium, uranium, thorium, etc. One of our views (Fig. 1) shows Madame Curie herself watching the distilling apparatus in which the nitrate of uranium is undergoing purification; the famous chemist is shown inserting a few milligrams of polonium between two disks of metal. In another view (Fig. 2) she is seen heating a solution of uranium in a water bath.

PREPARATION OF PURE RADIUM SALTS

To obtain pure radium salts it is necessary to subject first the ore and then the first crude salts obtained to an extremely laborious, complicated, tedious process—and it is this fact to which the enormous cost of the pure salts is largely to be ascribed. Luckily, however, they are extremely potent even in minute amounts. The finely crushed ore is first fused with carbonate of

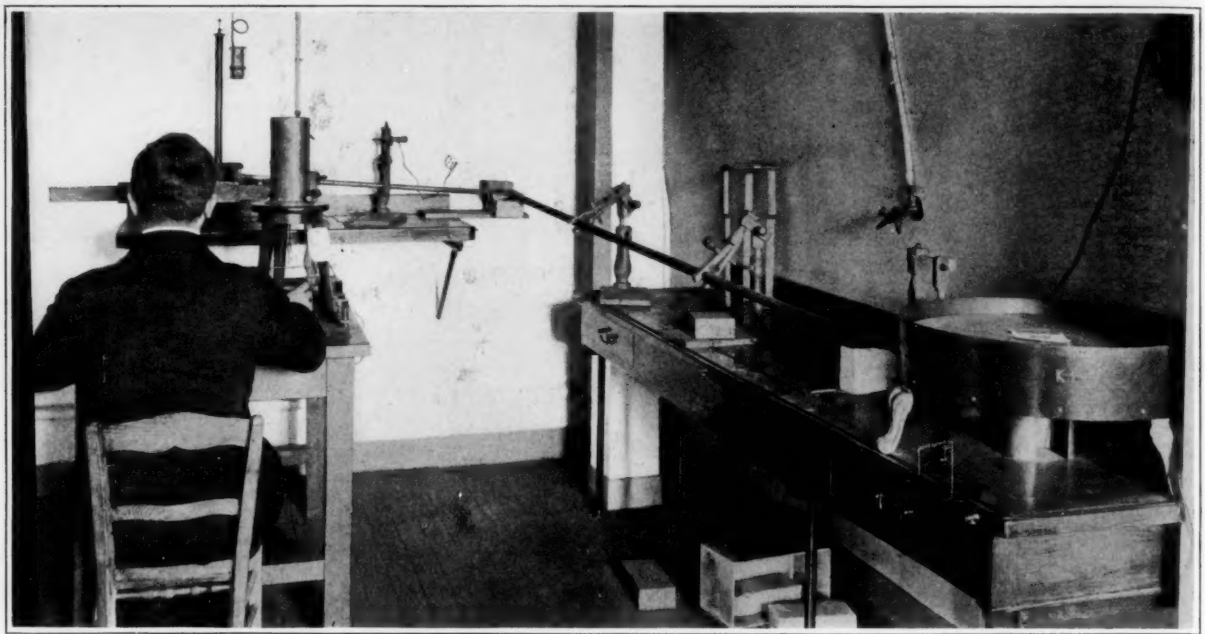


FIG. 3. STANDARDIZING RADIOACTIVE TUBES BY THE PIEZO-ELECTRIC QUARTZ METHOD

soda, then cooled and broken up, after which it is washed in water nearly at the boiling point to which a little sulphuric acid has been added. The fluid portion now contains all the uranium present, while the residue is treated with caustic soda to remove the acid; this process also removes the lead, calcium, and aluminum, leaving the radium ore reduced to a smaller bulk. This new residue is washed and hydrochloric acid added which dissolves any actinium or polonium contained, leaving the barium which contains the radium. The actinium and polonium are precipitated by sulphuretted hydrogen and collected, since they are likewise of value. To the residue sodium carbonate is now added, and later hydrochloric acid, which forms chlorides of the barium and the radium; these chlorides are then transformed into sulphates. The object of all this is to reduce the bulk and the process is repeated again and again until a ton of ore has been refined down to about 38 pounds. This bulk, which is already strongly radioactive, is now subjected to a series of practical precipitations by which means it is crystallized until finally a comparatively pure specimen of *radium chloride* is obtained. This chloride must pass through another long and tedious process before "commercially pure" radium bromide is obtained.

It is of interest here to quote Mme. Curie's own words in regard to the later stages of the process of purification. In her *Traité de Radio Activités* she says: "The process which I have employed for extracting pure radium chloride from radiferous barium chloride consists in fractional crystallization, first in pure water and then in very dilute hydrochloric acid. By this means I take advantage of the different solubility of the two chlorides, that of radium being the more soluble. I first make a saturated solution of the chloride in distilled water at the boiling point. This solution is then crystallized by being allowed to cool in a covered evaporating dish at the bottom of which fine adhering crystals form, so that the supernatant solution can be easily decanted. If a sample of this solution be evaporated to dryness the chloride obtained is found to be only one-fifth as active as the crystals in the basin. Thus the chloride has been divided into an active portion A and a less active portion B. The same process is repeated with each of these, two new portions—one more active than the other—being obtained from each. When the crystallization is ended the *least active fraction of the A chloride* and the *most active* fraction of the B cloride are mixed—these two being about equally active. By this means 3 portions are obtained which are submitted to the same treatment. The operation is repeated until the most soluble portion is so poor in radioactive matter that it can be eliminated. In the same way when a suitable amount of the residue which is the richest in radium is obtained that is also eliminated."

In brief therefore these elaborate operations result in obtaining a chloride rich in radium on the one hand and a nearly inactive product on the other. The treatment is continued until the crystals on the top represent pure radium chloride.

Perhaps the most remarkable room in the Radium Institute is that devoted to the extraction of the radium emanation. The radium compounds are kept in a safe, the sides of which are covered with sheets of lead. The radium salts are placed in glass vials provided with curved tubes connected with a mercury manometer. Some idea of the value of these substances is shown by the fact that $100,000 worth of one of them can be held in the hollow of the hand.

The radium emanation is generally preserved inside of flasks containing liquid air and for this reason a necessary part of the equipment is a machine for liquefying air (Fig. 5).

LUMINOSITY OF RADIUM COMPOUNDS

All radium compounds are spontaneously luminous. The salts lose much of this luminosity in damp air but recover it on drying. Very active preparations of actinium are also luminous and Becquerel has observed that crystals of uranium nitrate are spontaneously though feebly luminous.

In many experiments in radioactivity it is necessary to measure variations in activity of a substance over long intervals of time. This is done usually by an electroscope but since the sensitiveness of these and other measuring instruments is subject to alterations from various causes it is very desirable to have some simple means of correction. Such correction is made most easily by the use of radioactive standards.

IONIZATION STANDARDS

The most convenient substance to employ as a standard of ionization is the black oxide of uranium. This is ground to a fine powder and mixed with an organic liquid, e.g., chloroform or ether. The mixture is then poured over a plate of aluminum or copper. The liquid soon evaporates, leaving a

uniform, closely adherent film of uranium oxide. Practically all the ionization produced by these films is due to the alpha rays. The ionization current due to the active substance being observed is directly compared with that view to the uranium standard. The ratio of these two currents is independent of any variations in the sensibility of the measuring instrument.

POLONIUM

Polonium was discovered by Madame Curie and named in honor of Poland, her native land. It was the first active substance separated by her from uranium minerals, a ton of which had been presented to her by the Austrian government in the form of residues from the Joachimsthal mine in Bohemia. Madame Curie has succeeded in concentrating polonium by various methods and in obtaining preparations having a high degree of activity. These preparations were, some years ago, placed on the market in the form of films adhering to a polished disk or rod of bismuth. More recently Madame Curie has made further attempts to isolate polonium, obtaining preparations which are very highly active. She has also determined some of the lines of its spectrum. Polonium is one of the series of products resulting from the transformation of radium. Like the latter it is found in pitchblend but in amounts only 1/5000 part as great as the radium, which is itself, as we have shown, found in very small quantities. Convenient sources of polonium, however, are preparations of radio-lead in solutions of which polonium is produced at a constant rate, and from which it can be separated merely by tracing a bismuth plate in the solution. It has the peculiarity of emitting only alpha rays, the strongest line in the spectrum is designated as 4170.

FIG. 4. MADAME CURIE'S LECTURE ROOM

One milligram of polonium in the pure state has been calculated to emit as many alpha particles as 5 grams of radium itself. Thus an almost invisible amount of pure polonium will make phosphorescent screens brought near it brilliantly luminous. There is strong reason to believe that after the emission of a helium atom polonium turns into lead and it is believed that the transformations of the uranium radium series with lead as the final product.

URANIUM

Uranium, on the other hand, is highly complex; it has the highest atomic weight of any known element, namely, 238.5; it is usually separated from uraninite where it is always associated with ionium, radium, and actinium. The transformations which take place are from uranium to uranium X, to ionium, to radium and the series of products of the latter.

THE PASTEUR PAVILION

The Pasteur Pavilion, which as stated above, is an annex of the Pasteur Institute, is devoted to the treatment of cancer and tumors by means of radioactive substances and X-rays. In one of our pictures is seen a patient suffering with a facial tumor, undergoing treatment by means of X-rays. The patient's head is at a distance of about 20 cm. from the Coolidge tube. This apparatus is surrounded by a protective jacket. The physician, who is sheltered from the X-rays by means of a lead partition, observes the application through a window.

One hundred and twenty thousand volts are available for the radiotherapeutic treatment.

Preparing the Radium Emanation for Therapeutic Uses.—For curative purposes the emanation is confined in small glass

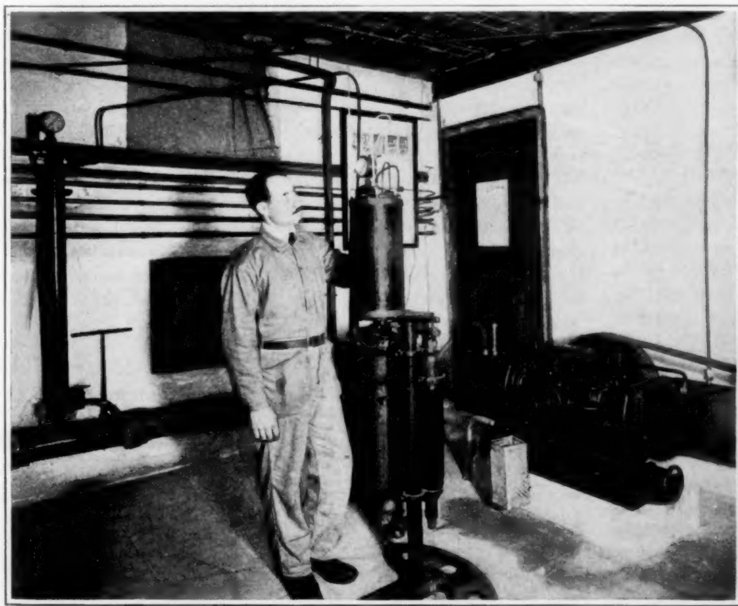


FIG. 5. THE MACHINE FOR LIQUEFYING AIR

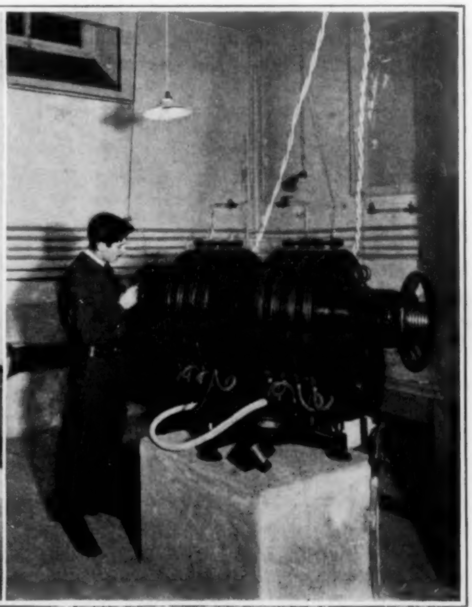
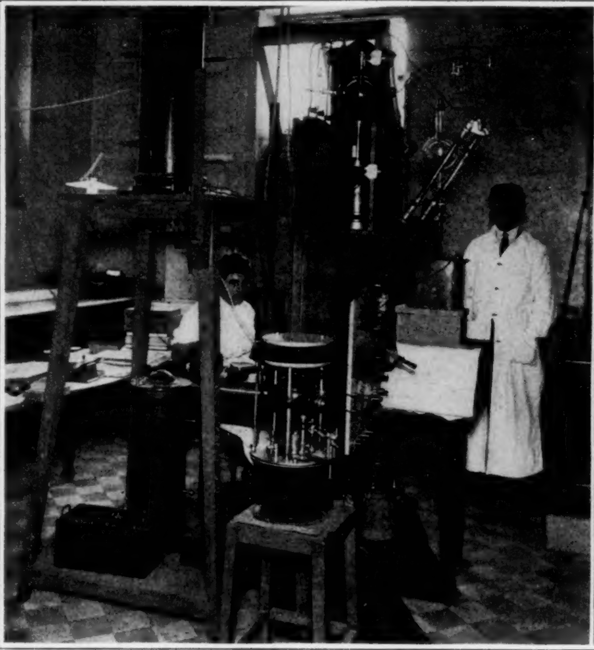
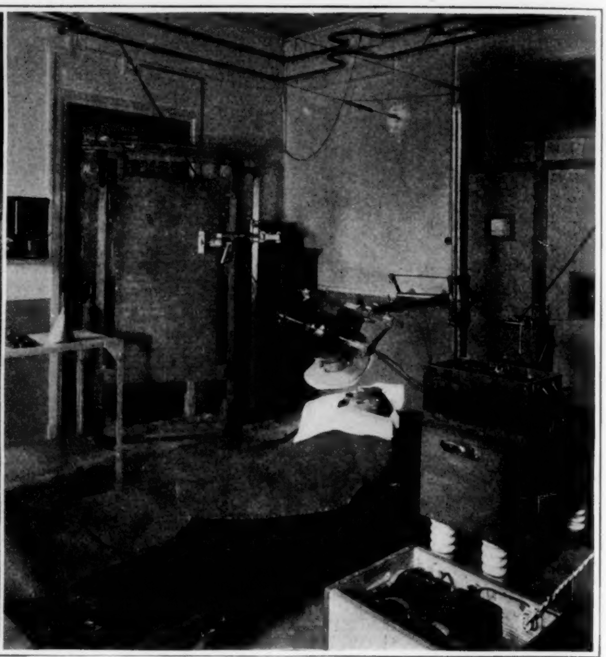


FIG. 6. A POWERFUL ELECTRO-MAGNET



APPARATUS EMPLOYED IN THE PASTEUR PAVILION FOR THE RADIO TREATMENT OF CANCEROUS TUMORS



PATIENT RECEIVING RADIO TREATMENT. NOTE THE LEAD SCREEN BEHIND HIM

tubes of two general sizes; the larger are about 0.6 mm. in diameter and 10 to 15 mm. long, and when first made contain from 100 to 250 milicuries of the emanation and sometimes even as much as 400 mc. The smaller tubes are about 0.3 mm. in diameter and 3 mm. long; each of these contains from 1 to 4 mc. of the emanation.

The "dose" of radiation employed for curative purposes is specified in mc.-hours per square centimeter of the surface treated, the total amount of emanation used and the total area also being stated. A very recent application of this treatment in dental practice is by the use of bare tubes. Writing in *Radium* (New York), Gioacchino Failla, Ph.D., says explicitly, "during the last two years we have treated a great many patients by inserting tiny emanation tubes into the growth by means of a steel trocar and *leaving them to decay in situ*. We had previously used steel needles with a tube of emanation at the end according to the method of Dr. Stevenson of Dublin, with considerable success in certain cases. The new method, however, proved to be far more effective and of wider applicability."

CURATIVE USES OF RADIUM SALTS AND RADIUM EMANATION

The present extensive use of preparations of radium by the medical profession for therapeutic purposes is largely due to the brilliant researches of the English physician, Dr. Wickham—so much so that a leading authority has declared that in the medical use of radium there are two epochs—"Before Wickham" and "After Wickham." The various methods of application are chiefly comprised under 5 heads: A. *Long applications.* The apparatus used for these exerts a mild effect and can be employed for long periods, even for infants. B. *Very brief applications.* For these very powerful instruments with large surfaces, and unscreened, are used. The time of exposure is from half a minute to one minute. C. *Fractional doses.* The action of the radium rays on organic tissues depends on the manner in which a given amount of energy is applied. The total amount sometimes yields better results when divided into fractional doses. D. *Applications at intervals.* Variable effects are produced by applications at varying intervals. It is necessary for these to be carefully observed and regulated by the physician in charge of the case. E. *Internal applications.* Radium preparations enclosed in tubes can be introduced internally in treating diseased portions of the body. They are sometimes covered only with rubber, but at others are covered with lead or aluminum screens.

Experiments on animals have shown that radium has a marked effect on the nervous system, especially the central nervous system. Thus, when a tube containing 1 centigram of radium was placed beneath the skin of a mouse one month old, exactly over the spinal column and part of the skull, the little creature developed paralysis in 3 hours' time, was seized with convulsions at the end of 7 or 8 hours and died in from 12 to 18 hours. Mice a year old live from 6 to 10 days under such conditions. Such experiments seem cruel enough at first glance, but they have pointed the way to the relief of severe cases of neuritis and facial neuralgia.

RADIUM EMANATIONS

In the destruction of disease germs the emanation has been found more useful than the direct rays—killing or checking the growth of anthrax, typhoid and diphtheria germs. Of especial interest is the proved value of radium in the treatment of rheumatism, that too common scourge of the old. Dr. Guyenot says concerning this: "Uric acid circulates in the blood in the form of urate of soda, of which there are two isomeric forms differing from each other by their respective solubility in the blood plasma. The soluble salt is converted into an insoluble form," urate of soda. Radium breaks up this compound. Dr. Guyenot has succeeded in effecting entire cures of severe cases of rheumatism by radium.

SKIN DISEASES, CANCERS, TUMORS, ETC.

The most extensive therapeutic applications of radium are for affections of the skin and for abnormal growths. Its healing power is directly connected with the fact that it possesses a remarkable selective power with reference to its action upon cells. As we have seen, it was the *young* mouse which was most seriously and rapidly affected. Similarly it is *young* and rapidly growing cells in an adult body upon which it makes its selective attack. Since such cells are formed in tumors and cancerous growths, it at once becomes evident why the radium destroys *these* abnormal tissues before acting upon normal tissues.

Is Heliodor a New Gem?*

An Instrument for Examining the Luminescence of Precious Stones

SOME little time before the outbreak of the war the announcement was made that a very brilliant new gem of a dazzling golden luster shot with green, *i.e.*, changing into green under artificial light, had been discovered in German Southwest Africa. Specimens of this magnificent new gem were presented to the Emperor and Empress of Germany in artistic settings designed by the distinguished painter, Lucan von Cranach. The happy thought occurred to the latter of bestowing the name heliodor, *i.e.*, the golden sun, upon the new stone. Dr. Alfred Eppler writing in *Die Umshau* while acknowledging von Cranach's gifts as an artist, does not hesitate to say that he had practically no technical knowledge of gems. He, thereupon, raises the question as to whether heliodor really is a new gem and, incidentally, discusses entertainingly the qualities that properly constitute gems, *i.e.*, precious and semi-precious stones, and the scientific and other tests proper to determine these qualities. He remarks:

The stones were cut in Idar near where they were found and the gem cutters there said at once that this was by no means an unknown new stone but a seldom observed variety of the beryl, adding, that this brilliant golden color is oftener found among the aquamarines of Brazil and Madagascar. Previous to its exploitation in newspapers, however, because of the gift to the Kaiser it was not highly valued in the jewelry trade. The German company, which had made the gift apparently made a shrewd use of this exploitation, stimulating the public curiosity but refusing to throw the stone upon the market. This naturally irritated the Idar gem dealers. They hunted up the yellow beryl which they had previously laid aside as having little commercial value in spite of their beauty, sent them to the cutters and sold them under the new name heliodor. The colonial company which had presented the original "heliodor" was much disgruntled by this action, but since the name had not been protected as a trade-mark the Idar jewelers were as free to sell their greenish-yellow beryls from Brazil and Madagascar under this name as the German Colonial Company theirs from German Southwest Africa. The Colonial Company thereupon took steps to prevent the Idar dealers from sharing in the enhanced price of the yellow beryl, publishing the following statement:

"*Heliodor.*—The article which appeared in No. 19 of the '*Woche*' and in the trade paper '*Die Goldschmiedekunst*' of June 7, 1913, has been the occasion of the receipt by us of numerous inquiries from gem dealers and jewelers concerning this stone; furthermore, similar material also designated heliodor has been offered to us and to other interested parties. These latter stones of different origin from our own failed to meet the test to which they were subjected. The uncut gems coming from our mines are few in number, and have not been given by us to the trade. We, therefore, beg all interested persons to be extremely cautious in their own interest with respect to the purchase of all stones purporting to be true 'heliodor.' Signed Deutsche Kolonialgesellschaft für Südwestafrika, Berlin W. 35, Am. Karlsbad 10."

Upon this announcement a number of jewelers returned the Idar stones to the consignors, and the matter soon threatened to form a very pretty legal dispute. Dr. Eppler, being a well-known gem expert, was approached from various quarters among gem dealers and jewelers with the request for an authoritative pronouncement concerning the truth of the matter. He very wisely determined to settle the matter if possible out of court by scientific methods, knowing that the sort of dispute in question does either party less good than the damage done to both the domestic and foreign trade. He, therefore, determined to endeavor to obtain specimens of their heliodor from the Colonial Company in order to subject them to a searching comparison with the Idar stones.

He says: I readily obtained the desired specimen of Brazilian and Madagascar stones from Idar, but was not successful in getting samples of their heliodor from the Colonial Company, the excuse being that they had none on hand, but that some stones were on their way from Africa.

Some time later I had the opportunity, however, of seeing some of the heliodor belonging to the Colonial Company, since in the exposition of the Deutschen Werkbundes, held in Cologne in 1914, the heliodor jewels belonging to the Imperial couple were exhibited, with special arrangements to show the change of color by artificial light . . . skilfully disposed electric lamps reveal that by such artificial light the play of green in the stones was somewhat more marked than in daylight. But in spite of repeated visits to the exhibit I was unable to perceive an actual change of color like that seen in Alexandrite, in spite of the fact that I have an uncommonly good eye for shades of color; so far as I could observe there was merely such an alteration of color as is commonly seen by artificial light in amethysts, many sapphires and other stones.

During my visits to the Exposition I was fortunate enough to meet Professor van Cranach in person, and after a good deal of trouble I finally succeeded in obtaining from him the loan of a few specimens of uncut heliodor, including the remainder of the crystal from which the stone of the Kaiser's scarfpin was cut. He lent me, for the purpose of scientific investigation, six pieces of crystal, the biggest weighing 43 3/64 carats and the smallest 7 47/64 carats. Unfortunately I was not able to obtain a cut stone.

Chemical investigation made by experts at the Technological Institute of the University of Berlin led them to conclude that heliodor belongs to the beryls. Its yellow color appears to be connected with its content of iron (0.55 per cent of iron oxide). The signed report sent me by these experts contains the following statement: "Upon the basis of these results we hold this mineral to be a new variety of emerald." This opinion is entirely incomprehensible to me and probably to any other authority on precious stones. The emerald is, indeed, also a beryl, but it owes its distinction from other beryls to its small content (cc. 0.3 per cent) of chrome-oxide; thus it might be termed chrome-beryl just as we speak of caesium-beryl, whereas, under the same system of nomenclature heliodor would be called iron-beryl, consequently, heliodor is no more nearly related to the emerald than is any other beryl.

Hauser and Herzfeld (the chemists referred to) listed the following features as characteristic marks in similar forms of beryl:

1. A plainly perceptible bluish phosphorescence under the influence of cathode rays.
2. A change of color from yellowish green into dull gray under longer exposure to the cathode rays.
3. The mineral is opalescent and exhibits a clearly perceptible though faint green fluorescence. Under artificial light the greenish tint becomes stronger.
4. A feeble radio activity probably connected with its content of uranium.

This communication lay before me at the time when I received from Professor v. Cranach specimens of heliodor for a further investigation. Since I was obliged to give him an express and positive promise that under no conditions would the stones be allowed to receive the slightest injury, I was not able to determine the density through the examination of

*Abstracted for the *Scientific American Monthly* from an article by Dr. Alfred Eppler in *Die Umshau* (Frankfurt a M.) for Aug. 21, 1920.

a piece of the pure mineral, but was obliged to make my estimate from the entire stones including impurities, flaws, etc. Under these conditions the best calculation I could make gave the figures 2.683, whereas, the density of beryl varies between 2.67 and 2.76. The refraction of light also (exponents of refraction) of beryl, also coincide very closely with that found for the heliodor. As respects the *characteristic color* I observed that the six crystals of heliodor lent me by v. Cranach differ greatly in tint; as a matter of fact there was a greater difference between these specimens than between them and the greenish-yellow beryls from Brazil and Madagascar, employed for comparison. When the latter were mingled with the African stones no one could tell them apart merely by the variation of the color. In order to test the stones also with respect to their luminescence I communicated with the chemist Bernhard Jost in Duisburg and conducted my further investigations together with him. This expert has at his disposal a considerable number of preparations of radium, ionium, actinium, and polonium. To conduct our tests he made use of a capsule containing 125 mg. of the purest radium bromide. Herr Jost is a well-known technologist in the domain of the experimental application of various forms of radiation. I had already some time previously tested together with him a tube invented by Professor Riedl of Vienna, for the investigation of luminescent phenomena in precious stones and kindly lent to me by him.

AN INSTRUMENT FOR EXAMINING LUMINESCENCE IN PRECIOUS STONES

This Riedl tube was of the utmost service to us in the investigation of heliodor and of the beryls of light color from Brazil and Madagascar. It enabled us to examine the stones, both with X-rays and with cathode rays. In my presence, Jost subjected all the stones to both sorts of rays, and this was usually done in such a manner that the African stones and those from Brazil and Madagascar were exposed to the radiation at the same time.

We observed that under the X-ray neither of the two kinds of stones was luminescent in a vacuum, while under the cathode rays, on the contrary, the stones from Southwest Africa shone with a magnificent luminescence while the beryls of light color from Brazil remained unaltered, failing to exhibit the phenomenon of luminescence. But it is a significant fact that the six specimens of heliodor from Southwest Africa also varied among themselves, the phosphorescence of some of them being violet blue, that of others rose color and of still others reddish yellow. It follows from these results that the heliodor from Southwest Africa can be readily distinguished from the beryls of the same color found in Brazil and Madagascar by means of the cathode rays in a vacuum or in a highly rarefied atmosphere. We have at present no information concerning the behavior of the beryls of similr color found in North America. An attempt to record the heliodor radiation upon a photographic plate produced no results after an exposure of twenty-four hours. We next exposed to the radiation given forth from 125 mg. of radium bromide, the specimens of heliodor obtained from v. Cranach, together with two from Brazil, two from Madagascar and blue beryl from Brazil, with the result that the blue beryl exhibited the strongest luminescence, the two greenish-yellow beryls from Brazil exhibiting the next degree of brilliance while the luminescence of the heliodor from Southwest Africa was fainter and that of the two beryls from Madagascar was faintest of all.

WHAT CONSTITUTES A PRECIOUS STONE?

Before we discuss the question as to whether the difference in luminescence is sufficient to justify the giving of a distinctive name to the beryl from Southwest Africa, we must first consider whether it is allowable to give a distinctive name to greenish-yellow beryls in general. This question may be promptly answered in the affirmative. Aside from the emerald a number of other beryls have received distinctive names because of their individual coloring. We have already mentioned the caesium beryl found in the State of Maine, which varies in tone from colorless or rose color to a bluish tint. The greenish blue beryls found in Siberia, Brazil, Madagascar, and elsewhere are known as aquamarines; all possible intermediate shades are found in aquamarines, from a sea green on the one hand to pure blue on the other, while some of them are colorless. But it is the custom, nevertheless, to speak of blue aqua marines and of white aqua marines instead of blue and of white beryls.

Morganite is a pink beryl, specimens from Madagascar exhibiting an especially beautiful color. Bixbite is a gooseberry red beryl from North America. A number of other names are applied in the United States to various kinds of beryls (compare "Gems, Jewelers' Materials and Ornamental Stones of California" by Lewis E. Aubry, Sacramento, 1905). I believe I am correct in supposing that these North American stones also include some of the same color of heliodor. . . . In view of the consideration stated above it is my opinion that the giving of a distinctive name to the beryls from South Africa, merely because of the difference in luminescence is unjustified. The rubies from Ceylon, Siam and Burmah differ greatly with respect to their luminescence, some specimens exhibit practically none while that of others is very strong—but no one would think of confining the name ruby to any one of these stones of different origin, merely because of this difference in luminescence. I may cite another example apropos to this: Mr. Hugo Wild of Idar said to me, of some colorless specimens of the precious topaz from Southwest Africa which I compared with similar stones from Brazil, the former gems showed a strong luminescence in the cathode rays, while those from Brazil showed none, yet it would be absurd to give the topaz from Africa a different name from that of Brazil.

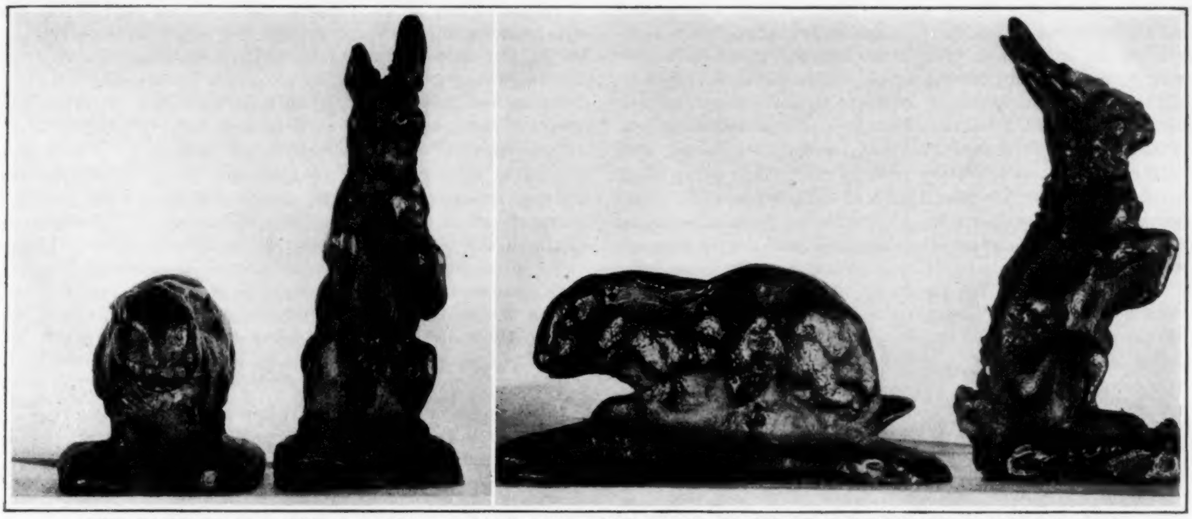
It is my final opinion that distinctive names for the same mineral are justified only by a distinctive color which can be readily distinguished by the naked eye, irrespective of any variation of luminescence which can be detected only by a delicate scientific test.

ELECTRIC FURNACE REFRACTORIES

R. M. HOWE, in a paper before the Electric Furnace Association in Columbus in October, described the properties of refractory brick and discussed the raw materials employed in the manufacture of such refractories.

The fusion points of refractory brick are stated as follows in degrees centigrade: Fireclay, 1615 to 1715; silica, 1700 to 1705; magnesia, 2165; chrome, 2050; bauxite, 1565 to 1785; zirconia, 2563 to 2600; carborundum decomposes at 2240 and alundum fuses at 2050.

In the article, which appears in *Chemical and Metallurgical Engineering*, December 22nd issue, a proper use of these various refractories is discussed and the electric resistivity is given together with data as to the thermo conductivity of refractory brick at a thousand degrees centigrade and the resistance to temperature changes. In conclusion the writer states certain factors concerning the service secured from refractory brick. "They should be protected from rain while being stored in order to prevent the weakening of their structure. They should be laid up with a material similar to the brick themselves or one which would not corrode or flux them, using as small a joint as possible. The furnace should be constructed so that heating will be conducted away from the hotter portions. The ratio of heating to cooling area should be made as low as possible and refractory brick or shapes should be heated from one side only in order to keep the heating surface low and in order to avoid the effect of pressure and high temperatures. Insulation lowers the margin of safety and should therefore be avoided even to the extent of allowing dust to accumulate on the roof. When the furnace is being heated this should be done gradually, especially where magnesite and silica brick are involved. When a furnace is being cooled it should be remembered that cold blasts produce or accelerate spalling."



TWO SAMPLES OF NATURAL PATINA—A RICH, SOFT DEAD BLACK PRODUCED WITHOUT HEAT TREATMENT

Patina—Natural and Artificial

Various Methods of Producing Colored Coatings on Metallic Objects

By C. Powell Karr

THE name "Patina" is applied to the colored coating or incrustation more or less permanent, that is produced upon metals or their alloys, either by natural or artificial means.

The first and most beautiful coloring is produced by nature. The tooth of time is the best corrosive and the moisture of the air with its vapor laden with many different active gases is the best dip or wash that can be devised. The beating of the winds, the falling of rain and hail, the blanketing of the snow and the buffeting by the weather and the intermittent play of the sunlight produce, by a combination of mechanical and chemical action upon the object a softer tone, a deeper tint, a more ravishing effect than can be imitated by any or all of the ingenious devices originated by man for the same purpose.

All common metals and their alloys by exposure to the air are altered, little by little, until a permanent coloration or patina is brought about. Sulphuretted hydrogen, ammonium sulphide or other impurities of the air, such as carbonic acid, intensify the coloring. Oxides, hydroxides, carbonates and sulphides are formed on the surface of the metal. The coloring produced is various, in fact the whole gamut of colors visible to the naked eye, from yellowish brown through indigo, blue to green, to black. Inhumation of the object in moist earth for a long time will produce an effect almost as beautiful as that attained by exposure to the air and weather. Examples of natural patina formation may be seen in coins, medals, public statues, fountains and monuments everywhere. One of the most beautiful examples in all the world may be seen and admired by a study of the statue of George Washington, in front of the Subtreasury Building at the corner of Wall and Nassau Streets, New York. The upper parts of the statue above the knees are colored a rich, deep chocolate brown with a dull soft velvety patina. From the knees down, the rich lustrous glittering surfaces, rubbed down by the palms of some one's hands are colored by a combination of the oily moisture exuding from and rubbed in by those hands and the beneficent lapping of the wind and softened by the sunlight. The effect is incomparably rich and permanently beautiful.

The two little figures shown herewith in two different positions, were modeled after the celebrated Barye bronzes by an art-bronze sculptor and metal artisan of Italian birth and training, but now a good American citizen. Their composition is as follows: the standing figure has: 83% copper, 7% tin, and 10% lead. The recumbent figure has: 83% copper, 5% tin, 2% zinc and 10% lead. The original heats were made in an oil-fired furnace, poured into ingots by the writer, sent to Brooklyn, N. Y., where they were cast into these little figures by a well-known art-bronze founder. They have received no heat treatment, but have remained for four consecutive years in a steam-heated apartment in Washington, D. C., that was lighted by electricity. No gas was present except that from the kitchen range to which they were not exposed.

Both of them have the rich, soft dead-black patina referred to later, in an alloy that happens to be of the same composition as that of the recumbent figure. The vertical figure possesses a patina if anything a shade deeper and more lustrous than that of the recumbent figure. As beautiful examples of a natural patina on a small scale they could hardly be surpassed by anything of the kind ancient or modern now extant.

Some years ago the writer had occasion to make up a pewter alloy containing about two per cent of copper. After the casting the remaining metal was poured into a cast-iron mold. Out of sheer curiosity the writer watched the ingot mold. While undergoing solidification the coloring took place. At first a warm blood-red brown appeared, followed rapidly by a lapis-lazuli and azure blue, then by a malachite green, then by tints of pale mauve green, simultaneously by a purple of Cassius, by a soft delicate violet and finally by a red, brilliant, startling, flaming as the richest coloring of a dying sunset; then slowly by hazes of purple, violet, lilac and the pale pinks of a morning's late sunrise in November, with a transparency as clear as if they had been cast under molten glass or translucent enamel. This astonishing transformation fixed one's attention and held it spell-bound at such a color drama, with its bewildering abundance and variegation of blended and contrasted colorations.

The colors thus produced are not permanent. Upon continued exposure to the air—even of a closed room—they are attacked in such a manner that their brilliancy and glassy luster fade or become dull. The colors seem to run under

the transparent skin of the metal while it is still semi-molten, and are produced by a film of oxides on the skin of the molten casting; it is probably impossible to repeat or reproduce them upon spun or drawn metal of the same composition, such as britannia metal or pewter, because they originate only at the transitional moment from a molten to a solid state. It might be possible however to reproduce such a wonderful patina by the Parazite process referred to later on, or by suddenly heating such a drawn or spun surface in various places by playing a spirit flame upon it at different moments and then suddenly cooling the object by plunging it suddenly into a bath of liquid air. If such effects could be reproduced by artificial means it would bring back to the world the lost art of making pewter mugs, jars and pitchers—the wonderful and admirable creations they used to be.

ARTIFICIAL PATINA

Such coloring is a work of art. It obtains a subtle hold upon the admiration of man from a period reaching back to the dawn of the earliest civilization of the world. The Greek alchemists produced some of their color effects by the use of mercury and arsenious sulphide.

Everybody knew that in melting together 90 parts by weight of copper and ten parts by weight of tin a hard brittle alloy of yellowish color of bronze was produced. It was seen that a small quantity of tin mixed with molten copper furnished new properties and a golden color, and from these alterations of color they came to the conclusion that by similar changes base metals might be transmuted into gold. The coloring agents were covered by the family name of "The Philosopher's Stone." That by a corresponding surface treatment (surface alloying, treatment with mercury, arsenious sulphide, golden yellow, varnish, etc.), colored metals were denoted by the names of the imitated metals. A special object of metal coloring in ancient times was the bronzing of them, which was carried out with masterly effect. Since then bronze coloring has been shaded and varied by changing the proportions of the alloy, by artificial or natural oxidation, by naked corrosion and by gilding processes that produce a true patina formation.

In the most admired of the Japanese patinations are to be found methods which differ greatly from the art as practised by other countries. They found that by protecting parts of the surface of an object by shellac or varnish and leaving other parts exposed to the action of the corrosives they succeeded in evolving some striking effects. Also they combined their art of inlaying one metal or alloy with another and, etching the combination with the proper corrosive, attained brilliant results. Then too the metals they used were smelted from ores containing many impurities that they had not learned how to extract so that their supposedly virgin metals contained other metals not especially desired, but which at the same time secured to them enviable reslults. Cobalt is found in many of their alloys; it is there as an accident, not intentionally, but, having a wonderful effect when it is present in a copper alloy, its presence was turned to the best account.

ELECTROLYTIC PATINA

By anodic action a colored metallic coating is brought about due to the gases generated at the anode. In order to retard the evolution of the gas or to decrease it, gelatinous bodies such as gelatine, agar-agar, etc., are added to the electrolyte. In the best way the metal object is colored by placing the thickening material and the electrolyte in a clay or porcelain cell; the electrolyte at the cathode is left free and open. A solution of mono- or di-sodium carbonate ought to produce a dark brown; by the addition of a di-sodium thiosulphate a deep black coating results. By sodium acetate an olive green, by potassium ferricyanide and ammonium chloride a rich lilac coloring.

Black oxide can be applied to iron as well as to copper or brass. The solution consists of hydrochloric acid, 3/4 of a liter, water, ¼ liter; arsenious acid 25 grams, copper sulphate, 5 grams. First of all dissolve the arsenious acid in the hydrochloric acid, stir with a glass rod until solution is complete. For the other part dissolve the copper sulphate in a 1/4 liter of water (preferably not to hasten the reaction); to this solution add the solution of the arsenious acid. Then electrolyze the bath, taking for an anode a suitable sheet of iron; for the cathode use the object to be patinated. This object naturally should be scoured perfectly, as it acts upon the coating no matter what the metal deposit is. Employ two amperes per square decimeter of the surface to be covered; continue the operation during the time necessary to obtain the desired deposit. For copper and brass, cool down from a high temperature, polish with a little plug of cotton. The patina obtained is fine, susceptible of being revived and better still, burnished. In the last case the result is beautiful.

BLACK PATINA

Space will permit only a reference to this coloring as applied to brass. The brass article is polished and colored by an amoniacal corrosive as follows: 100 grams of copper carbonate is dissolved in 750 grams of ammonia of 0.96 spec. gr. (the commercial product), in which the corrosive is allowed to stand for several days in a closed vessel and frequently shaken; then 150 grams of distilled water is added. Some copper carbonate remains undissolved. The corrosive is cold or warmed to about 60° C. but nòt boiled. Since the air acts upon the coloring process the dipped objects are moved back and forth. The copper carbonate (basic carbonate of copper) can be used in the form of mineral blue, it is better, however, to precipitate it afresh, in which a soda solution is added to a solution of copper vitriol; both solutions to be hot, not boiling. (Under "Electrolytic Patina" see another method for obtaining a black patina.)

PATINIZING ALUMINUM AND ITS ALLOYS

The Parazite Co.G.m.b.H. Frankfort a.m. uses a proprietary solution called "parazite;" it is dark brown and transparent in color. The composition of it is a trade secret, but it is probably nothing more nor less than a paraffin or ceresine wax dissolved in a paradibromobenzene, or other benzene compound solvent. It is alleged that this solution does not attack the metal object that is to be colored, that it is absolutely resistant to acids, alkalies, atmosphere, etc. The solution is applied in thin or thick layers, according to its concentration, by means of brushing, dipping, or spraying as may be most suitable. It spreads easily, gives a smooth surface, even the brush strokes are not visible. The brown coating dries quickly. If the object be dried slowly, with a temperature rising gradually to 200° C. and left so for 25 to 30 minutes, then slowly cooled, at the beginning there appears a transparent coating of fast adhering, deep black upon the surface that is constant up to 300° C. (The decomposition temperature of paraffin.) It is claimed that by heating as described, and by the oxygen of the air the solution is polymerized and changed into another modification. The preparation is first melted, but by subsequent heating it is altered in such a way that no further heating is required. Carbon-disulphide and carbon tetra-chloride are solvents of paraffin wax but their boiling points are so low that it is not believed they could be used successfully in the above operation. It is admitted by the Parazite Co. that the patina obtained by their process is injured by the action of steam.

PATINATING BY HEAT TREATMENT

The surface of any alloy, especially one containing copper, is changed in its coloration aspect by the sudden application of heat almost up to the fusion point, followed by sudden or slow cooling. The color effects are more or less brilliant and permanent, respectively. Evanescent coloring may be made permanent by lacquers. This is a branch of the art that was greatly in vogue among the ancient alchemists and is now looked at askance by modern lovers of the art of patination.

The application of a hot gas or vapor to the surface of a metal or its alloys is just as logical and esthetic as the use of a solution of a liquid for the same purpose. We believe that such an attitude is a pose and not a sincere expression of a conviction. Any method that will bring about a coloration of a metallic surface, whether the result be evanescent or permanent, should be studied and developed. One art begets another art and although some of its creations may turn out to be grotesque or hideous, yet insensibly and subconsciously they point out the path to beauty and beauty always has been and always shall be its own excuse for being.

An alloy consisting of 5 parts of tin, 83 parts of copper, 10 parts of lead and 2 parts of zinc (by a singular coincidence the same composition as that of the recumbent rabbit of the illustrations) after polishing, if heated in a muffle furnace, quickly assumes the dead-black so greatly admired in Chinese specimens. Hitherto it has been found difficult if not impossible to obtain this depth of color with modern art bronzes, since the surface scales off when treated under similar circumstances. A different view, however, is that if to such an alloy, during its compounding, one per cent of cobalt be added, the dead-black produced by alternate heating and cooling will not scale off.

About a year ago the writer made up some test bars of the following composition: 90% copper, 6.5% tin, 1.5% lead, and 2% zinc. These were heat-treated in an electric muffle furnace, held at a constant temperature of 600° C. for thirty minutes; allowed to cool slowly over night in the furnace. The specimens have been lying with others in a storage bin since then. The surfaces of the test bars have the rich dead-black patina referred to above. The patina cannot be removed except by fresh chemical reagents. The patina does not scale nor peel off. The deep black is accounted for in part, probably by the lead that they contain. By rubbing the dull black with the fingers, the surface takes on a vivid lustrous black with a slightly reddish tint that seems to glint through the black, an effect that does not lessen its appeal to the eye. This test among many others of a similar character upon specimens of bronze varied in composition, but always containing some indispensable lead, shows that it is possible to produce upon a modern bronze a permanent patina—a dead soft ivory black matte or a lustrous dead-black with the forbidden red trying to gleam through its dusky mask.

Among the most beautiful patinas the world has produced is that devised in Germany by W. Elkan (D.R.P. 153308). It is a blood red or Dragon's Blood patina as it is sometimes called. It is produced as follows: Objects of copper or copper alloys are heated to a glowing red. The heat covers its surface with a film of copper oxide and cuprous oxide or copper suboxide. After cooling the object is polished with polishing wax until the black oxide film is removed and the sub-oxide deposit appears; in doing so the object attains an intensive red color, which at the same time shows a striking luster. Coloring and luster are so constant that the object may be treated by various chemicals such as copper vitriol solution without suffering any damage to its appearance. If a veined marble effect is desired, the surface, during the heating, is sprinkled with borax or other reducing agent. Wherever the surface is deoxidized by the reducing reagent the reddish virginal surface of the copper alloy appears and when polished a variegated or mottled effect like veined marble is produced after the final polishing.

Measuring Shades of Colors*

Dr. Ostwald's Mathematical Method of Defining Dye Tints

By Hans Heller

When we wish to make accurate measurements of a stretch of ground we make use of a graduated scale, so that we can obtain any required degree of precision expressed in divisions or multiples of a given standard, such as a meter—e.g. centimeters and millimeters on the one hand—kilometers, etc., on the other. Since the magnitude of these units of measure is exactly known and can be readily verified, the measurement of length offers no difficulty in practical life, and the same thing holds true not only of linear but of square and of cubic measure. Certain other values which cannot be reduced to measurements of space may still be easily recognized and represented by figures, such as the degrees of heat, amounts of pressure, and various others. The making of measurements where we have to deal with immediate sensory impressions as in case of notes of sound appears to be much harder, but this problem also is capable of being solved by "measuring" not the sensory impression but the corresponding *physical magnitude* which forms its basis. To every audible tone there corresponds one certain definite length of the sound wave which causes it or else a fixed number of such waves or vibrations per unit of time, the so-called velocity of vibration. The figures representing these velocities have been given names in the shape of letters of the alphabet compounded with certain words or syllables, and thus any note of sound can be measured with precision and so designated as to be generally comprehensible. Every lover of music knows what middle-C means and by means of such expressions (more exactly by means of their graphic representation in the form of musical notes) the chaos of sound tones can be mastered and set in order. But there is another immediate sensory impression, that of *smell* in which this method *cannot be employed*, and both the manufacturer and user are obliged to resort to the selection of certain well-known perfumes as standards and approximate measures of comparison.

And at first glance *colors* "the children of the light," which not only afford our eyes the liveliest pleasure from earliest infancy, but are the chief requisite for the formation of our concepts of the visible world—the colors with which we adorn ourselves and which form the medium of the artist—these too, appear to evade any method of *measurement*. Even men of science who have need of precisely defining mineral colors, dye stuffs, etc., and the technicians who require color designations and definitions, both in the textile craft and in countless others, even these men have felt obliged to content themselves apparently with inexact representations of more or less limited signification, such as "deep blue, sky blue, violet blue," etc., the apparently unlimited multiplicity of artificial dyestuffs has now, however, sternly emphasized the necessity of greater precision in the designation of shades of color. It is exceedingly troublesome and often enough quite impossible to make "color tests" when a certain color requires accurate naming. But when we look through the enormous handbook of dyestuff tables prepared by Schultz, we are unable to find any color terminology wherein *measurement of shade* is a factor.

The question "Can colors be measured?" which it is apparently difficult or impossible to answer, is obviously of a twofold implication. In the first place *what is it* that it is desired to measure? Helmholtz and most of the investigators who have succeeded him held the view that every bright color is characterized by three magnitudes which it is necessary to measure in order to obtain a quantitative definition—these properties being the color tone, the purity, and the brilliance. But the physiologist, Ewald Hering, has pointed out that these

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three properties cannot possibly be the elements which constitute a "color" quite aside from the fact that it is impossible to make an *absolute* determination of these three values so that it is necessary to rely upon merely comparative estimates. Hering's greatest service in the matter has been the relegation of the doctrine of color to that branch of science to which it properly belongs, namely, psychology. The sensation of color is obviously a mental experience and it is, therefore, in the domain of the intellect that we must seek for the answer to the question as to what constitutes the concept of color. Hering, himself, has largely solved this problem. However, we have been enabled to form certain *definite*—we will *not* say *final*—conclusions upon the subject, only quite recently through the researches of the celebrated physicochemist, William Ostwald, whose activities have been so manifold in various domains of science. . . .

We must first endeavor to obtain a clear idea of the concept of "color." Ostwald understands thereby merely the mental process by means of which we become conscious of color, no matter what the cause of the experience. This internal process to which we apply the name color undergoes profound alterations according to the circumstances which condition it . . . for example, let us lay a piece of bright colored paper, preferably yellow, upon a table standing by a window in the brightest possible sunshine. Then let us cut a circular hole about 2 cm. in diameter in a second piece of stiff white paper. Now let us hold the white paper at a distance of about 30 cm. above the yellow paper so that the latter can be seen only through the circular hole in the corner. If we now gaze through this hole it appears to our eye *at first* but not constantly, as a yellow circle in the middle of the white surface, but if we turn the white paper away from the window, so that it is in the shadow, the circle assumes a *brilliant yellow* aspect. If we now slowly turn the paper toward the light once more this vivid yellow begins gradually to lose its brilliance becoming increasingly duller, then grayish yellow, olive green, until finally when the white paper is receiving the full brilliance of the sunlight, the eye receives the impression of a blackish yellow circle in the middle of the pure white surface (of course, care must be taken to prevent a shadow from falling upon the yellow paper. . .). This is certainly a very remarkable and surprising experiment; although the color tone of the lower paper, as well as its purity and its brilliance, have remained *absolutely unaltered*, yet the color of the visible section has apparently changed gradually from a vivid yellow to a dark yellowish gray, passing through the most various intermediate shades! Here, as we see, the actual yellow color of the dyestuff has remained unchanged while the sensory impression has undergone manifold alterations. This experiment indicates that "color" is a mental process.

But let us now consider the *cause of this apparent change of color*. We can see readily enough that this change must be due to the fact that we have regarded the yellow circle in a constantly changing environment. Through a mental process which is entirely independent of our own will, we connect the two impressions with each other—we relate the color impression of the circle to its environment. For this reason Ostwald terms such colors *related colors*. It will readily be seen that impressions of such related colors are the general rule in our daily experience of color. We are constantly finding ourselves in varying circumstances through which our impressions of color are extensively influenced. . . . Let us make a parallel experiment: A tube having a blackened interior is closed at one end with transparent colored gelatine, a yellow filter, cobalt glass or the like. If we now place the eye at the other end of the tube, at the same time looking in the direction of the window, we perceive a surface of uniform color in an entirely dark environment. If, for example, we have once more chosen the color yellow, we perceive a brilliant yellow circle in a black field. If we now turn the tube slowly away from the window toward the darker room, then the *luminous intensity* of the yellow steadily diminishes, whereas the yellow as a *color* remains *constant*. And even when we are looking toward the darkest corner of the room we still receive an impression of a surface which is yellow though strongly shadowed. But at no time do we perceive the muddy yellow and olive green tones which we observed in the first experiment! The alteration of the intensity of the light, therefore, does not produce a change in the tone of the color in a dark environment, but merely occasions varying degrees in the brilliance which changes from the most intense to the palest tone. The reason for this lack of any alteration of the color tone evidently resides in the fact that there is no *relation* or reference to the surroundings which here exert no optical effect. Such colors are termed by Ostwald *unrelated*. They are found as a rule in all optical apparatus and, indeed, hardly anywhere else.

But what is the essential difference between related and unrelated colors and what is their bearing upon the measuring of color? When we examine *unrelated colors* with respect to which of their elements are alterable in the mental process, we find that there are two in general: (1) the color tone; (2) the brightness, for it is possible for me (1) to place either a red or a yellow object or one of any other color in front of my tube; I have, therefore, a choice of the color tone at my command. I can, likewise, (2) alter the brightness of any given color tone at will by varying the intensity of the illumination, but since this illumination is always accomplished by means of sunlight, *i.e.*, of *white* light—in other words light consisting of all possible wave lengths, then we may draw the inference: in unrelated colors the color tone and the content of white (*i.e.*, the degree of brightness) are alterable. This exhausts the possibilities and the *measurement of unrelated colors* is, therefore, attainable provided that both of these magnitudes can be determined—and, moreover, determined *quantitatively*.

Related Colors.—The case is different with related colors. Here, too, however, the color tone (1) can be chosen at will, while the content of white also (2) varies within the same limits as in the case of unrelated colors: the character of the first experiment will be in no way affected when its vividness is diminished because of a weaker illumination of the yellow paper. It is the influence of the environment (3) which is constantly to be regarded as alterable. This third magnitude, which is capable of causing related colors to appear to be so much more manifold must, therefore, be measured in order to find a mathematical expression for the measurement of related colors—*i.e.*, consequently for *all* the colors known to us. How shall we accomplish this?

In order to answer this question let us recall the general phenomena of colored bodies . . . when white light falls upon a body, either all the light is *reflected*, in which case the body appears to be white, or else all the light is absorbed, in which case we call the body black. Between these two boundaries lie all the cases in which the light is partly absorbed and thus weakened; these colors we refer to as "gray." These include the so-called neutral tones, *i.e.*, those which do not possess a color tone in the ordinary sense of the word. It is evident that we *are* able to measure such colors. This is accomplished in practice by the ordinary methods of photometry. *Absolute black* can be achieved in the Kirchhoff box, a black box containing a small opening. A coat of specially precipitated barium sulphate can be employed for standard white. In this case we measure merely the *luminosity*, *i.e.*, the *relation* between the quantities of light received and those reflected, hence we are concerned here with *conditions of reflection;* and these are determined merely by finding the percentage of "black" in the reflected light. This proportion or *content of black* is the third alterable factor in the value of related colors. At first thought this seems rather astonishing since obviously the bright colored filter placed in front of the dark tube in our second experiments, likewise permits only a portion of the total amount of light to enter the eye, so that

even with the fullest degree of illumination there still remains a content of black. Just here there is revealed, however, the basic importance of the relatedness or non-relatedness of the color to the environment. Since it is impossible for us either to have or to form an opinion as to the strength of the illumination in the case of unrelated colors, neither can we in general form an opinion as to the conditions of reflection! We cannot give in this case an extended explanation of these conditions which are not readily made comprehensible, but we may state in brief the manner in which the color tone is to be conceived of and measured.

Thus far we have taken the question of the reflection or absorption of white light merely as a basis for the discussion as to how the phenomena of the gray or neutral tones are produced. But we know that "white" light can be split into its components by a prism and is then seen to be made up of the colors of the spectrum, *i.e.*, of *bright* colors. Observation of these has shown that every color tone in the series corresponds to a certain wave length of electro-magnetic vibration. The brightness of the great majority of natural objects, *i.e.*, their *gay colors*, depends upon the circumstance therefore that it is not white light—*i.e.*, light constituted by *all* the wave lengths—which is reflected, but that certain waves which are characteristic for any given substance, are absorbed. But since the totality of wave lengths has the appearance of white, whereas any separate portion is colored, most substances appear in bright hues. But *besides* this partial absorption of certain rays of light there occurs, even in the case of those colors which appear to our eyes the purest or most perfectly "saturated," a certain amount of *general absorption of the total wave lengths*, so that any given color of an object contains not only its own color tone, but also a certain proportion of *gray*. This leads us to the obvious conclusion that the color tone can be determined only by a comparison of it with the *pure tone* which resembles it in spectrum, and that it can be "measured" by determining the wave length of the aforesaid pure tone which is a comparatively simple thing to do.

And just here lies the further service for which we are indebted to Ostwald—he points out, namely, that the common opinion that a "saturated" pigment or dyestuff reflects light of only *one* wave length is entirely erroneous; even the most beautiful yellow pigments of exceptional purity which it is possible to prepare by physical means, do not as a general thing reflect the corresponding pure yellow of the spectrum, but also throw back to the eye numerous waves of approximate length. As a consequence of this the *color tone cannot be expressed by figures representing wave lengths.* This is especially evident in the so-called *purple colors* which lie between red and violet, but as a general thing do not appear in the spectrum at all.

By means of this long-winded and yet really essential introduction we shall now find ourselves able to comprehend how colors can be measured. We shall explain here merely the basic principle without entering into the technical details. In accordance with the foregoing remarks there are three factors which enter into the determination of a color, namely, the color tone, the content of white, and the content of black.

. . . In the well-known experiment of illuminating a dark room by a *monocolored flame*, the aspect of ordinary objects undergoes a drastic change. When, for example, a gas flame is colored yellow by ordinary salt those objects which always observe the yellow rays from white daylight, naturally do the same thing in the yellow light—hence they reflect no light and, therefore, appear to be "black," whereas objects of a yellow color or *those which reflect many yellow rays*—appear on the other hand to be a pure white color, since a "white" object is merely one which reflects to our eye *all* of the light which it receives. This is why the hands and faces of the spectators look white and their ghostly aspect is not easily forgotten. The measurement of the purity of any given color in a colored object is accomplished in a similar manner. Let us imagine a spectrum of sufficient length thrown upon the screen and let us then take the object to be examined, e.g., a green leaf or the like, and pass it through the band of colored light—it will vary in apparent ripeness according to the color of the light which happens to fall upon it at any given moment of its progress. In that portion of the spectrum whose color tone is "like" that of the object being tested, *i.e.*, at that part of the spectrum where *all* of the light which falls upon the object is reflected, the latter will appear to be pure *white;* in that part of the spectrum, however, in which all of the light is absorbed the object will appear, on the contrary, to be absolutely *black*. But it is possible for me to compare the amount of the reflection in the two cases with that of a neutral gray pigment, the conditions of whose reflection are already familiar to me. Moreover, I can represent upon a decimal scale (divided into 100 parts) the content of black or white in the aforesaid neutral gray. Now the luminosity (represented by the symbol h_1) in the first described case may be considered to be composed of the following factors: the content of white (W) of the bright colored object plus the percentage of pure color (R), since the latter is also entirely reflected. This gives us the following equation:

$$h_1 = R + W$$

In the second case the luminosity which is measurable by means of a comparison with the previously measured gray, consists only of the percentage of white contained (W), since the pure color (R) is absorbed while the content of black produces no immediate effect; hence we have the equation:

$$h_2 = W$$

But as we know the total color of our green leaf comprises three factors: the pure color tone R, the content of white W, and the content of black S, hence:

$$R + W + S = 1, \text{ or}$$

$$R + W + S = 100, \text{ in the decimal scale.}$$

We first obtained from our measurement the value of $R + W$. Substituting this value in our first equation we obtain:

$$h_1 + S = 1 \text{ or}$$

$$S = 1 - h_1$$

thus we have *measured* S the content of black, and we have likewise measured the percentage of white, W, by means of h_2. This *readily enables us to calculate the content of pure color* according to the following equation:

$$R = 1 - (W + S).$$

We are now in possession of all the factors required for the *quantitative determination* of any color of whatever nature. It is well to keep in mind that the measurement of the percentages of white and black is *absolute, i.e.*, independent both of any sort of theoretical speculation and likewise of the intensity of the light employed, since the gray used in the comparison is subjected to the same illumination. Accordingly, Ostwald is justified in his statement to the effect that "the discovery of the absolute measurement of the purity of colors constitutes the most important progress attained in our knowledge of pigments." On the other hand it is of little importance that we are obliged to make use of an arbitrary principle for the purpose of naming colors. This arbitrary principle consists of the *color circle* proposed by Ostwald.

The so-called color circle consists of the arrangement of pure color tones in a circle in such a manner that the complementary colors stand opposite each other, and so that the shade produced by the optical mixture of equal parts of any two given color tones lies between the two. Such color circles are by no means new, having been previously arranged in various systems. Ostwald composes his of 100 tones. The reader may inquire: "Why only 100?" We may answer this by saying that while it is true that there are innumerable stages between the pure color tones, yet we have learned from experience that only about 100 of these stages or degrees can be definitely recognized. These are quite sufficient in practice and intermediate stages can be estimated, while as a matter of fact beyond certain limits (the so-called "psychical threshold value") the eye ceases to be capable of making

distinctions. In this color circle, therefore, we find all the *pure color tones* and *also the purple tones* which are lacking in the spectrum. . . .

Pure lemon yellow is marked zero because it is the most brilliant of all color tones; red is represented by 25, while 50 corresponds to ultra-marine blue (U-blue for short), 75 to sea-green, etc. By means of this scheme every color can be precisely identified by means of three mathematical expressions. For example, we may take the following:

30 x 12 x 51: the signification of this is as follows: 30 is the number of the color circle, *i.e.*, in the vicinity of carmine red; 12 is the content of white which is thus very small so that the red in question will appear to be very "deep" in tone; whereas the 51 per cent of black is not so strongly noticeable as might be expected. This gives us the impression of a comparatively pure saturated red. The percentage of pure color in this case would be represented by $100-(12+51)=37$.

Thus we have attained our object of a mathematical representation measuring each color. Every imaginable mixture of black and white with the pure color tone from the clearest purple to the dirtiest brown can be represented by three figures arranged as above. This gives us some idea of the profundity of the problem thus solved by Ostwald. A description of the matter is to be found in the work *Introduction to the Study of Color* (in German) in Reclam's Universal-Bibliothe No. 6041/44. . . . These results are already being employed in the domain of art. Thus, the industry of porcelain manufacture in Saxony has already employed, with great success, Ostwald's great color atlas, thus offering the first proof of its utility.

REPORT OF THE CHEMIST

THE work of the Bureau of Chemistry for the fiscal year ending June 30, 1919, has but recently appeared, but the 24-page pamphlet is worth careful examination since it indicates how wide is the field and how important the work of this scientific bureau of the Department of Agriculture. In addition to the large amount of work incident to the enforcement of the Food and Drugs Act researches have been conducted on sugars, sugar derivatives and syrup, and of these problems an interesting one is the project to produce a uniform cane syrup that will neither ferment nor crystallize. Work was well under way when it became difficult to obtain a kind of yeast necessary for the process and the research has now turned to an effort to obtain a satisfactory substitute. It appears that certain molds which are easy to grow may form sufficient of the enzyme invertase to make it possible to employ them in the place of the yeast.

Fats and oils have been an important part of the research and a bulletin upon the production and conservation of fats and oils in the United States has been issued. The demand for this first critical survey in the oil industry and traffic of any country has been great. The physiological chemical examination into the nutritive value of the oil-bearing seeds has received much attention and has thrown light upon the cause for the completeness of the Oriental diet which has seemed poor and inadequate to the average American. Data derived from these researches shows that cocoanut globulin contains all the basic acids necessary to growth and that it as well as crude cocoanut press cake is capable of supporting growth. These and other findings justify the opinion set forth in an earlier report that it is very desirable to retain a corpora crush industry developed during the war in this country.

Sea foods, poultry and eggs, dairy products, beverages, citrus by-products, flour and cereals, have all come in for their share of attention. Paper and fabrics, naval stores, leather and tanning, color investigations, containers, insecticides and fungicides and the dehydration of fruits and vegetables are the subjects of other interesting paragraphs. Researches into the causes of spontaneous explosions and fires in grain mills, elevators and cotton gins are also reported. Plant chemistry has included research on the seeds of about forty plants mostly grown in Illinois to determine their content of essential oils, and seeds from the varieties from which the largest yields of oil obtained have been planted at the experiment farm for further study.

CHINA'S OLDEST INVENTIONS

BY H. K. T. LOH

THE following is the result of a research through some oldest Chinese literature with the object of obtaining an authentic account relating to China's civilization in the line of literary and industrial inventions. No exact dates can be secured, however, on account of the fact that most of the books indicate only the names of the inventor or just an approximate period. Thus, here only the periods or dynasties are put down. As for the result, due to the lack of some important references which the writer cannot secure here, it is, of course, not complete. Besides, here are recorded only those which have relatively high value upon the latter development and those which bear deep significance on the early civilization.

From 2800-2698 B. C.—Ropes made of grass, and earthen pots. By Suy Jin.

Fishing net, cloth of hemp, and musical instruments as bamboo pipes. By Paou He.

Grass mat, wooden plows, bamboo combs, iron axes and earthen jars. By Shin Nung.

From 2697-2598 B. C. Under the Great Ruler Huang-ti.—Rough pottery, rough rice mill, spinning wheel, mirror, scissors, cooking utensils, water click, umbrella, dyes and magnetic needles. By Huang-ti.

Boat. By Ku Hua Wu.

Carriage. By I-yi.

Carving on wood. By Tso-che.

Rough astronomical instrument. By Yung Ching.

Tang Dynasty, 2357-2256 B. C.—Embroidery, wine, carving on stones.

Sung Dynasty, 2255-2206 B. C.—Painting and coffin. By Sung.

Hsia Dynasty, 2205-1784.—Metallurgy, tables, chairs, etc., sails and oars. By Yu.

Ying Dynasty, 1783-1123.—Candles, copper utensils, gold rings, earrings, etc., toilet powders from leads.

Chow Dynasty, 1122-247 B. C.—Bamboo curtain. By Chow Kung.

Sun dial, copper coins round in shape with a square hole at the center, shields and spears, elementary trigonometry, carpenter's plane and chisel. By Lu Pan.

Chinese ink. By Ying-yi.

Chinese ink stand. By Chung Yu.

Elementary machines began to be used in this period as derricks and automatic ladders. The latter was used during the siege of the capital of the kingdom of Sung by the kingdom of Tsoo. Their inventor was Kung Shoo Pan.

Ching Dynasty, 246-207 B. C.—Wonderful bows from which arrows were propelled with a slight touch on it. The one who touched it could instantly be killed.

Han Dynasty, 206 B. C., 219 A. D.—Paper. By Tsai Lun. The materials used were cloth, hemp and trees. (Before this time words were written on cloth and bamboo slips.) Sugar. Coal was discovered during this period.

The Period of Three Kingdoms, 220-274 A. D.—Turning carriage used in gardening. By Ma-chung. It poured out water contained in the carriage automatically.

Wooden animals used in pulling carriages. By Choo Ko Liang. It was also written in the history that Ma-chung could make wooden idols to beat drums and blow pipes.

Tsin Dynasty, 275-588 A. D.—Steel. By Chiwu Hwae-wan.

Suy Dynasty, 589-626 A. D.—Glass, improved water clocks.

Tang Dynasty, 627-935 A. D.—Gunpowder.

Five Kingdoms, 936-959 A. D.—Printing. By Fang Tao.

As this investigation is based on facts about the oldest inventions from the opening of the historical period to 1000 A. D., all the others later than this date are excluded here.—*The Little Paper* (Manila, P. I.), Nov. 17, 1920.

THREE YEARS' TEST OF SHINGLE ROOFS TO DETERMINE ADVANTAGES OF PAINTING

Note fungus growth and warping of the unpainted shingles in the cut at the left as compared with those in the cut at right, which were painted with fire-resisting shingle paint

Spray Painting*

Recent Developments in the Application of Paint with the Air Brush

By Henry A. Gardner

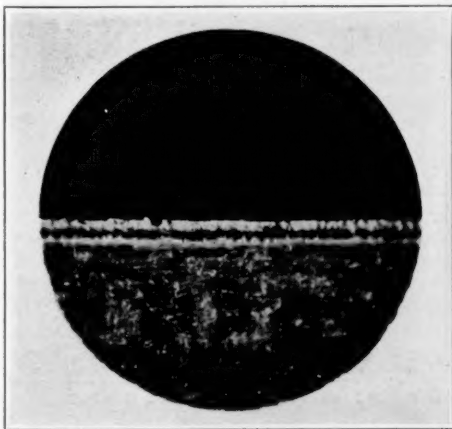
THE use of the spray gun for painting has encouraged a broader use of paint, especially for interior purposes, and has developed a wider demand for the services of the painter in general. Millions of square feet of wall and ceiling area in factories, which might not otherwise have been coated, are now being sprayed with interior paints of high reflecting properties. Such work has, in turn, created a wider use of paints for surfaces that can only be successfully done with hand brushes. As an illustration, the writer remembers one large factory, the owners of which apparently did not care to pay the cost of applying paint by brush. This factory was subsequently spray-painted with industrial white. The dado and the striping, of course, were found to be more successfully applied with hand brushes. The tremendous increase in light that resulted from the reflecting properties of the paint, coupled with the fresh, trim appearance of the mill, made that section that was partitioned off for offices look gloomy by contrast. In a short period of time all of the offices were transformed by the use of paint, and for this use the hand brush was employed.

It would appear to the writer, as a result of this and other similar instances that have come to his attention, that the application of paint by any means (from the woman who paints the chairs in her kitchen to the spray painting of a mill), will be reflected in a broader use of paint and consequently increase the demand for the services of competent painters and journeymen. In the following text there are presented a few observations made during the past year and several illustrations that may be of interest.

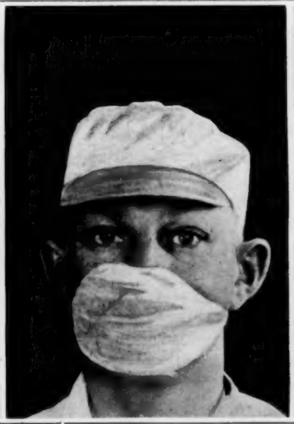
Durability.—The tests of spray versus brush painting, conducted at the U. S. Naval Hospital in September, 1919, and described in the pamphlet entitled "A Study of the Practicability of Spray Painting," were inspected during December, 1920, after exposure of about fifteen months.

It will be remembered that the exterior brick walls of the building were painted with a light buff paint, one-half of the area being brush-coated and the other half spray-coated. The wearing properties of the paint applied by the two methods

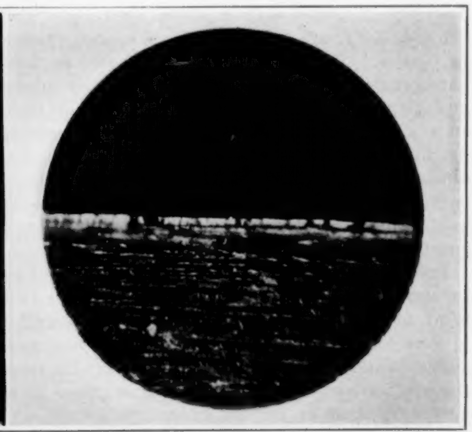
*Paper presented before the Pennsylvania State Association of Master Painters, Reading, Pa., January, 1921.



PHOTOMICROGRAPH OF CROSS SECTION OF WOOD COATED WITH SPRAY GUN. FIRST COAT WHITE, SECOND RED, THIRD WHITE

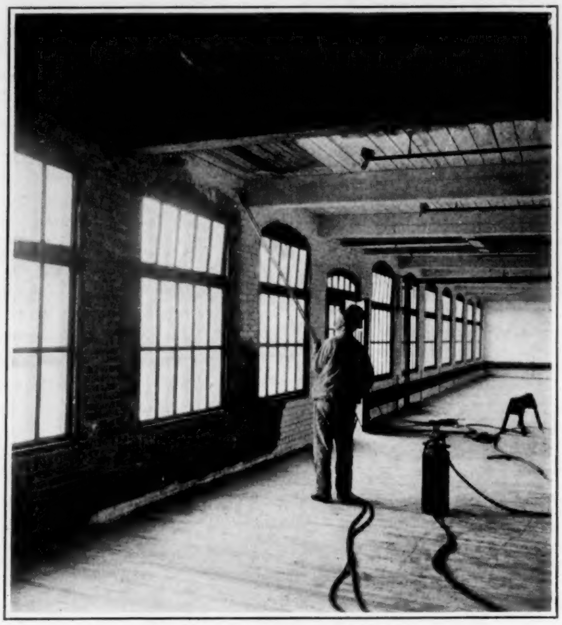


RESPIRATOR USED BY PAINTERS TO PREVENT INHALATION OF SPRAY FROM THE GUN



PHOTOMICROGRAPH OF CROSS SECTION OF WOOD COATED WITH HAND BRUSH. FIRST COAT WHITE, SECOND RED, THIRD WHITE

seem to be almost the same, both coatings being in fair condition. Medium chalking has developed and some unevenness of the yellow tint is shown in the form of light colored spots. The latter defect, however, is often characteristic of paints tinted with ochre. Close inspection of the two surfaces with a high power magnifying glass indicates a rather characteristic spatter effect where the paint was applied by the spray gun, and ridgy brush lines where the paint was applied by brush.



DAYLIGHTING A FACTORY
Note extension spray equipment

Inspection of the large roof area painted with red oxide paint showed that the brush-coated and spray-coated paints are giving equal satisfaction from the standpoint of durability. Where the paint had been applied with spray guns by workmen not acquainted with this method of application, excess quantities which were piled up in some instances, had run together with the formation of a somewhat wrinkled film in spots. Such films, remaining rather soft, necessarily took up dust from the atmosphere and became slightly darker than the areas coated with thinner films.

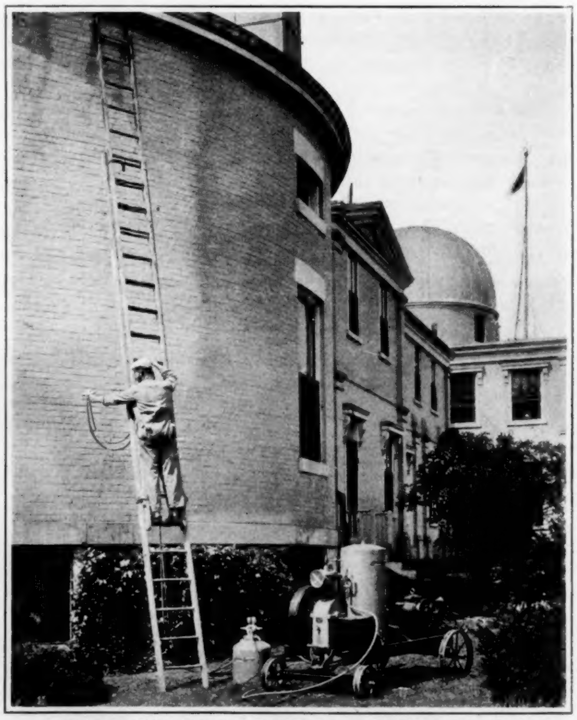
Due to the fact that the spraying machine, especially in the hands of inexperienced operators, is apt to apply a larger quantity of paint over a given area than the hand brush method, the heavier film would, of course, show slower drying properties. With certain paints, therefore, which are ordinarily made with raw linseed oil and a minimum of drier and thinner, slow drying properties might be observed. In such instances, the use of a substantial percentage of a rapid drying reducing oil of the varnish type would overcome this difficulty. A small percentage of a heavy bodied blown oil to cause "flowing out" and thus obliterate spray pit marks, might also be advocated. Manufacturers of special spray paints might take these points into consideration.

Paint and Industrial Relations.—The use of paint is bound to play in the future a very important part in the establishment of proper industrial relations. Cheerful surroundings in a factory make more contented employees and increase the quantity and quality of product. Proper illumination through the application of wall and ceiling coatings of mill white is now recognized by factory executives as one of the most important means of obtaining these results. For instance: James Copeland and Graham Lee, in writing on the subject of "Insurance and Safety," refer to a group of 106 Southern cotton mills as follows:

. . . "The precautionary measures taken inside of the mill are even more vigorous than those employed on the outside. In the first place, the mills of today are constructed so that they are not only efficient from the manufacturer's standpoint, but are healthful from the worker's standpoint as well. There are many big windows which let in a world of sunlight. To augment the flood of light that comes in through these windows, nearly every mill interior is painted with a specially prepared white paint which has a satinlike finish and reflects the light as it comes in through the windows until the mill interior is almost as light as day." . . .

Answers to an inquiry made among users of spray guns for applying industrial whites, state that on an average one workman can apply as much paint as six brush hands; two men being able to apply at least 50 gallons of paint in one day by well regulated spray guns.

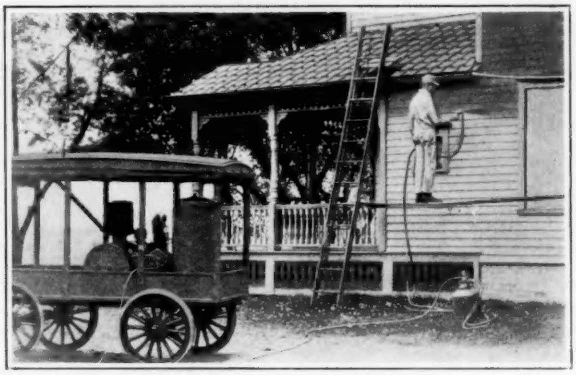
Sanitation.—In considering the subject of sanitation, the thought was advanced during the discussion at last year's meeting that painters working in rooms with a spray gun might be subject to the inhalation of small amounts of paint that had been finely comminuted and dispersed throughout the air. Accordingly, workmen in certain places have been provided with various types of masks, helmets, or other devices. Most of these are heavy, difficult to keep on, and expensive. The writer has devised a type of mask which is sanitary, light in weight, easy to adjust, and very low in cost. The design, with representative home-made samples, was turned over gratis to manufacturers, and the product is being made in considerable quantities. It consists of two sheets of gauze containing a pad of absorbent cotton filled with a small amount of activated charcoal. The mask is cross-stitched and so arranged that it will fit closely over the nose. A detachable elastic band is provided to go around the head. The purpose of the activated charcoal is to absorb the vapors of benzine, acetone, or other volatile solvents. The purpose of the cotton is to keep out dust and particles of pigment. Reports from several users indicate that it has been found quite practical and successful in application.



SPRAY PAINT TEST AT THE U. S. NAVAL HOSPITAL

Community Painting.—Many observing individuals have pointed out that on their trans-continental tours they have

been impressed with the lack of paint on structures in many communitifies. This condition, however, is not always to be attributed to the property owners' negligence. For instance, in many farming communities there may be a so-called painting season, in which the country painter is called upon to do more work than he can possibly handle. Consequently many buildings are neglected, and the owners hold over their painting work from year to year. Again, while some farmers fully appreciate the value of painting, they realize that the application of paints is an art, and if the local painter is not available to do the work, the job is left undone. In some communities there are no painters, and the farmer must do his own painting or let it go. The latter procedure often prevails, and results in rapid depreciation in property values.



PAINT SPRAYING A DWELLING
Note the trailer outfit

There seems, however, to be a rapidly growing movement throughout the country for community spray painting. For this purpose there are provided trailer outfits comprising a small truck upon which has been mounted a portable spraying machine operated either by electric current or gasoline engine. Supplies of hose, ladders and painting equipment are also included. With such an outfit the barns, dwellings, fences, silos and other outbuildings on several places in a farming community may be painted in a very short period of time. Because of the rapidity of application by this method, substantial savings may be effected. It is believed that this method of painting will become more universal in the future and thus help to fill that gap between demand for and availability of labor that often exists.

Spraying Shingles.—The potential use of paint for shingle roofs is immense. In every agricultural and suburban section there are thousands of structures with shingle roofs that have not been painted. The modern demand for a fire resistant type of roof now makes it important that all shingle surfaces should be coated with high grade mineralizing paints. Through the use of such paints, shingle roofs become fire resisting and waterproof. A glance at the condition of the many roof tests being conducted at the Shaw Botanical Gardens in St. Louis by H. V. Schrenk in coöperation with the lumber and paint industries, at once forcibly illustrates the value of shingle paints. The spray gun is very well adapted for the rapid coating of shingle surfaces, and the possibilities of the community spray gun for this purpose are apparent.

Decorative Purposes.—For interior decorative purposes, unlimited possibilities are opened up by a type of spray gun recently brought out by one manufacturer, which consists of a portable air compressor, including a motor, and gun attached to a small paint container. The total apparatus weighs less than 100 pounds and is so arranged that it may be attached to a standard electric light socket in any room. With pressures of from 4 to 10 pounds and by varying the distance of the gun from the work, extremely artistic two-tone color effects, including those which resemble Tiffany finishes and oatmeal paper, may be produced. It is understood that only extremely small amounts of paint mist are observable in the air when spray guns are used at such exceedingly low pressures, and that for this reason there is far less danger of soiling floors and the furnishings of a room when walls are being decorated by this process, than by other methods.

Imitating Mother of Pearl*

Methods of Producing Coatings Having an Iridescent Luster

By O. W. Parkert

IT is not generally known that the art of imitating the pearl and its close relative, mother of pearl, is very ancient. Almost since history began artisans have been trying to obtain the iridescent luster of mother of pearl by means of mixtures of various pigments. The methods that have been devised for this purpose necessarily have been very numerous. In certain Chinese books, about 3,000 years old, mention is made of certain formulæ in which different substances are compounded and from which mixture pearls can be made, possessing a high brilliancy of color. During the course of the centuries the attention of technologists was turned to this problem, and in the workshops of these investigators Nature was forced to yield her secrets. After considerable study, lasting over a period of many years, the way in which the pearl is formed in the shell of the mollusc was discovered, and, as a result, a plan of artificial cultivation of pearl-bearing oysters was developed. This was the outcome of careful and very laborious research. Very good imitations of the pearl have been made from various artificial substances such as glass preparations made from fish scales, etc. The results of these labors opened up the road to the afore-mentioned goal, namely, the reproduction of colored opalescent effects, resembling the mother of pearl iridescence, on various materials by means of paints and other analogous coatings.

At the present time there are many kinds of substitutes for mother of pearl on the market. The way these are made and what they actually consist of are so well known that it is needless to discuss them here. In the first place, there is very little to be said about them that is new, and in the second place, much better results can be obtained with the use of iridescent paint coatings, which can be applied to any sort of substance and which then will give them the superficial appearance of mother of pearl. As can be understood very readily, the methods of obtaining these substitutes for mother of pearl have differed very greatly.

For example, in the case of certain materials, as glass, porcelain and the like, the opalescent coloring can be acquired without any difficulty by the addition of certain zinc salts in the course of manufacture, whereby the objects are subjected to the action of the vapors of these salts during burning. However, the task is a much more difficult one when the material to be treated is wood, horn and other similar substances.

THE USE OF GELATINE COATINGS

A certain iridescence can be obtained by coating objects with a gelatine composition, containing a very small quantity of an insoluble silver salt. The opalescence is improved very considerably when an additional thin coating of transparent collodion is applied. On the average, the composition of the gelatine consists of 5 to 7 per cent of its weight in potas-

*Translated for the *Scientific American Monthly* from *Kunstoffe*, 1920, 129-130.

sium bromide, ammonium chloride or ammonium bromide. First, the objects are coated with this mixture and then a solution of a silver or mercury salt is painted on the gelatine film. After this has dried thoroughly, a coat of collodion is applied.

This method of obtaining iridescence is basic in its principles and from it newer methods of imitating the pearl were developed. All the truly practical processes are based on the fundamental principle of breaking up the rays of light, which are refracted from the surface of the coatings by the use of several superimposed films. This is the way in which Nature forms the genuine pearl itself.

LEDUC'S METHOD OF MAKING IRIDESCENT GELATINE

Dr. Leduc of the University of Nantes in his work entitled "The Chemical and Physical Relations in Life," describes in some detail a method of producing iridescent gelatine. A ten per cent gelatine solution is made and for every 5 ccm. a drop of a solution of calcium nitrate is added. The gelatine is then spread out on a glass plate and, as soon as it solidifies, a mixture of dibasic calcium or sodium carbonate and phosphate are allowed to diffuse through it. The best proportion is 2 parts of carbonate for each part of phosphate. The tribasic phosphates of the alkali metals yield fine results without the addition of carbonate. Tribasic calcium phosphate will result in the formation of beautiful fine stripes in pure gelatine. A saturated solution of silver cyanide in potassium cyanide will give a handsome lattice-like appearance to the same substance. When the solution is allowed to drop on the surface of the gelatine, the circular regularly arranged effects are produced.

When the solution is applied to the gelatine between rectilinear parallel glass plates, then regularly spaced rectilinear bands are obtained. The grating effect, produced in a colloidal substance by calcium phosphate is not any different from the luster of the natural mother of pearl and the pearl itself. The chemical structure and composition are identical. The physical properties of the artificial product, the rainbow coloration, the luster and the fire in the color are quite like the play of colors in the genuine mother of pearl.

THE INTERFERENCE OF LIGHT RAYS

Liesegang[1] was the first to formulate the theory that the iridescent surface color of the pearl was due to the interference in the light rays refracted through several very thin films. Hence, it was only a question of coating the objects with a number of suitable substances in solution, which would dry out to form thin transparent films. For this purpose soaps, rosin solutions, petroleum and various lead salt solutions were found to be most useful.

IRIDESCENT COATINGS ON PAPER

Besch, for example, produced the iridescent effect on paper by allowing the paper to float on the surface of a solution of lead and bismuth salts. Then the paper is dried and subjected to the action of hydrogen sulphide gas. When the dried film is coated over with collodion the opalescent play of colors, characteristic of mother of pear, is obtained.

Another formula for obtaining the same results consists in dissolving one part of sugar of lead in 5 parts of boiling water and adding thereto another solution, consisting of one part of gumarabic in 3 parts of water. The object which is to be decorated is painted with this boiling liquor, allowed to dry and then coated over with a top coat of varnish, consisting of one part of Damar rosin in six parts of petroleum ether.

THE USE OF POWDERED MICA

Attempts have been made to get the same effects on wood by the use of powdered mica, but the results have fallen far short of the expectations. The preparation, made from fish scales, when used pure and with the help of gelatine or rosin varnish, gave thick silver-like films but without any opalescent luster. Many of the imitation mother of pearls are useless practically, as the processes devised for making them do not admit of industrial application.

IMPORTANT PATENTS

Numerous patents have been taken out on processes for producing artificial mother of pearl, but most of these are not of any great importance as many of the processes are really intended for other purposes. The most important patent, as far as we are concerned, is German Patent No. 113114 on the manufacture of iridescent gelatine films. The gelatine is first provided with an insulating coating of chalk, barite (BaSOA), metal bronze, zinc white and the like, and then is dipped in a bath containing as little of the solution as possible. This is done by pouring into the vessel a mixture of one part of nitrocellulose, 75 parts of 95 per cent alcohol and 20 parts of ether in water. When the gelatine foil is drawn out of the bath a thin skin forms on it, which, when dry, gives the characteristic iridescence of mother of pearl. It is of advantage to add some benzine to the iridescence producing mixture. Another composition contains 10 parts of potassium silicate and 90 parts of water.

According to German Patent No. 126675 the aqueous solution of gelatine is mixed with ammonium bromide, the dried product is dipped into a silver nitrate solution, dried again and the film is finally covered with collodion.

THE AUTHOR'S OWN PROCESS

This process is an outcome of long experience with the various processes in use, and can be employed for different purposes. It has always given the best of results. Wood, horn and similar materials are painted over with a coating of albumen, collodion or varnish lacquer before treatment, while paper, textiles, etc., are given a coat of gelatine, which is hardened afterward by treatment in a formalin bath. The resulting products are then coated with a gelatine size which should contain about 1.5 per cent of ammonium bromide to give the best results. This coating is allowed to dry and then another coat is applied, which consists of a silver nitrate solution, containing 1.3 per cent $AgNO_3$.

The next step is to dry the nitrate coat thoroughly. Then still another coat of a composition containing gelatine and from 0.15 to 2.5 per cent of ammonium bromide, according to the desired intensity of the iridescence, is applied. The final coat consists of a solution of collodion cotton. On the face of it, this process is very difficult to carry out and consumes a great deal of time. Nevertheless it possesses one distinct advantage in being absolutely reliable. In general the practical way of applying the process is to dissolve about 20 grams of gelatine in 100 ccm. of water and to dilute this solution with 100 ccm. of water containing one gram of ammonium bromide. This gelatine solution is then used to coat the object to be treated. Then the latter is dipped in the 1 per cent silver nitrate solution, dried, and finally coated with collodion or a protective varnish. Iridescence is produced by the action of the silver nitrate.

If it is desired to produce real illusory effects on the aforementioned objects, then the essence made from fish scales is added to the gelatine solution, used to give the first coating. The rest of the process follows in the same manner as above. The play of colors is seen for the first time, after the combination of this coat with the first bromide film takes place and may be intensified to any desired degree by the application of other coatings. As can be readily understood, instead of collodion which is really only a protective coating, any other transparent varnish can be used. It may also be mentioned that the iridescent effect can be obtained with the help of opalescent varnish lacquers. These lacquers are especially effective when used as a top coat on gelatine undercoats. The author has also developed methods of making water white phenol resin solutions, which were used to produce the mother of pearl opalescent effects by mixing various salts with the resin solution.

[1]See *Zeits. für Chem. v. Ind. der Koll.*, Vol. 12, pp. 181, 188.

Problem of Preventing Dust Explosions*

Causes and Factors Affecting Dust Explosions and Types of Industrial Plants Affected

By David J. Price

At the present time the prevention of dust explosions is commanding the earnest attention of engineers of all classes both in the United States and abroad. This is quite natural, since many engineering problems have been developed in the study of dust explosions, their causes and prevention. Before these explosions can be prevented, it is necessary to understand fully their nature and behavior. This means a determination of the various causes and circumstances under which dusts may be ignited; the manner in which the explosion spreads or propagates; the ignition temperature of the various dusts; the pressure that will be developed during the explosion, and also the effectiveness of any methods which may be designed for prevention.

It is not the intention to consider in this article the simple causes that have been established since the study of grain dust explosions was undertaken by the Federal Government. It is well known that disastrous explosions have resulted from the ignition of flammable[1] dusts by matches, open flames, lanterns or torches. The attention of engineers at the present time should rather be directed particularly to the mechanical causes, especially those which occur during the handling of organic materials.

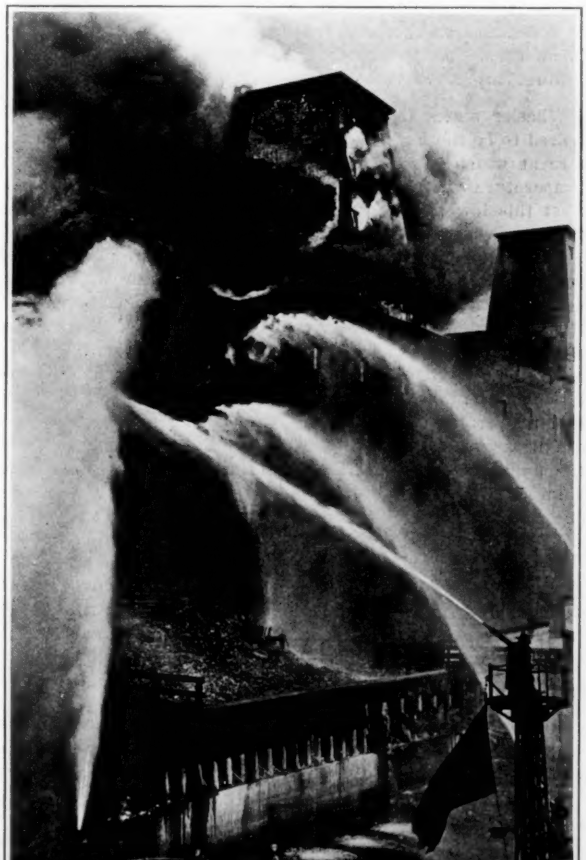
*From *Chemical and Metallurgical Engineering*, Jan. 5, 1921.

[1]The National Fire Protection Association, the National Safety Council and similar oranizations are now using the word "flammable" instead of the old word "inflammable." Some persons have misinterpreted inflammable, thinking of the first two letters of this word as the prefix *in* whose meaning is *not*, as in inactive (not active), or incombustible (not combustible). Flammable is not only a shorter term, but a more definite one, and furthermore is one which cannot be misunderstood. The negative of flammable is non-flammable.

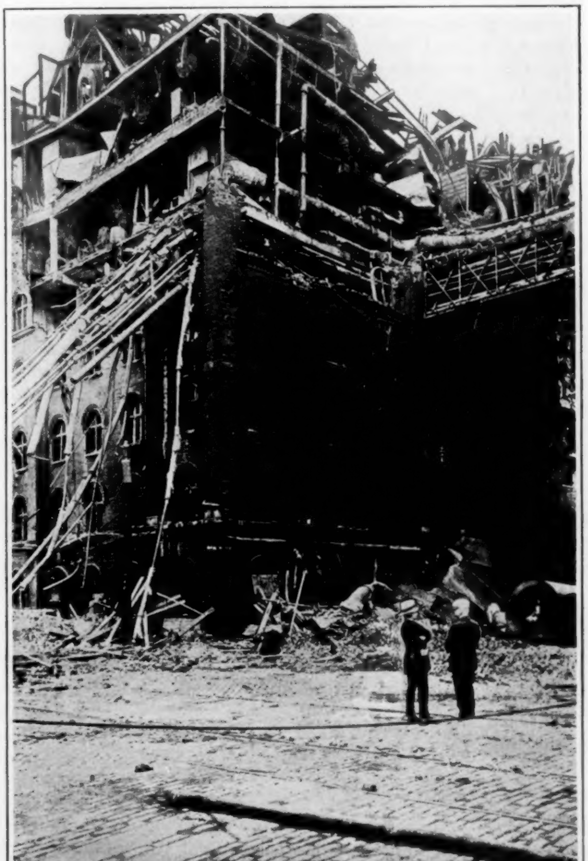
TYPES OF INDUSTRIAL PLANTS

In order to understand the nature and extent of dust explosions it is essential that consideration be given to the kind of industrial plants in which these explosions are occurring.[2] Dust explosions have occurred most frequently in plants where grain or grain products are either milled or handled, such as grain elevators, flour mills, feed and cereal mills and starch factories. Disastrous explosions have occurred also in sugar refineries, cocoa and chocolate plants, candy factories, spice works, wood-working establishments, paper mills and printing plants, shoe factories, fertilizer works, cork-grinding plants, drug and herb works and similar types of industrial plants where dusts are created. Explosions of aluminum and magnesium dusts have also taken place. Many disastrous smut and grain dust explosions have occurred in threshing machines in the Pacific Northwest, while a large number of fires

[2]The study of the cause and prevention of coal dust explosions is being undertaken by the Bureau of Mines, United States Department of the Interior, while the work pertaining to the cause and prevention of dust explosions in industrial plants is being carried on in the Bureau of Chemistry of the Department of Agriculture.

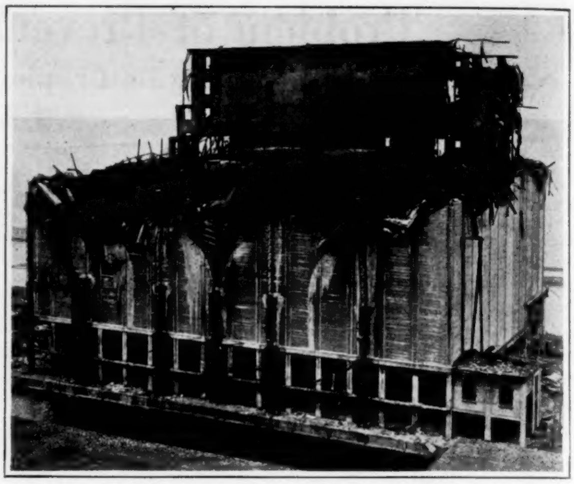


DESTRUCTION OF A GRAIN ELEVATOR IN NEW YORK HARBOR FOLLOWING A DUST EXPLOSION



A SUGAR REFINERY BADLY DAMAGED BY AN EXPLOSION OF SUGAR DUST—TWELVE LIVES LOST

STARCH FACTORY IN IOWA COMPLETELY DESTROYED BY STARCH DUST EXPLOSION. FORTY-THREE LIVES WERE LOST AND $2,000,000 PROPERTY DAMAGE WAS DONE.



GRAIN ELEVATOR, PORT COLBORNE, CANADA, AT ENTRANCE TO WELLAND CANAL, BADLY DAMAGED BY GRAIN DUST EXPLOSION—TEN LIVES LOST

have also occurred in cotton gins during the ginning process.

Since May, 1919, a series of very disastrous explosions have occurred in the United States and Canada, resulting in the death of over eighty-eight persons; injury to a large number, and property damage in excess of $7,000,000. Three of these explosions have occurred in grain elevators, one in a feed mill, one in a starch factory and two in flour mills. In the starch factory explosion forty-three lives were lost and over $3,000,000 damage was done. Fourteen lives were lost in one grain elevator explosion and ten in another, both explosions being very violent and doing extensive damage to property. In an explosion of "aluminum dust"[3] in a Northwestern factory six girls lost their lives and as many others were injured. A recent explosion of "hard rubber" dust in a Michigan plant resulted in the death of eight workmen and has attracted considerable attention.

IGNITION TEMPERATURES OF GASES AND DUSTS

From the experimental work which has already been conducted it appears that a dust explosion is very similar to a gas explosion. Although particles in a dust cloud are larger than the minute molecules in a gas mixture, yet the nature and behavior of a dust explosion appears to be very much the same as a gas explosion. To produce a gas explosion it is necessary that a proper mixture of gas and air and a source of ignition be present. The same condition exists in connection with producing a dust explosion. It is as impossible to produce a "spontaneous" explosion with dust as it is with gas. In both cases the explosive mixture must be ignited by some external source of heat or flame.

In order to obtain some idea as to the relation between dust explosions and gas explosions it will be of interest to note the ignition temperatures of the more common flammable gases in air as determined by Dixon and Coward.[4]

Gas	Ignition Temperature Deg. C.
Carbon monoxide	644 to 658
Hydrogen	580 to 590
Ethylene	542 to 547
Methane	650 to 750
Ethane	520 to 630

A series of experiments was conducted by R. V. Wheeler, chemist attached to the Explosions in Coal Mines Committee of England. In the first series of tests an effort was made to determine the temperature at which the dust would ignite and propagate flame. A second series of tests was conducted to determine the lowest temperature at which ignition could be effected. The following results were obtained:

Kind of Dust	Ignition Temperature, Deg. C.	Temperature of Flame Propagation, Deg.
Dextrine	540	940
Sugar	540	805
Starch	640	960 to 1035
Flour	650	1060
Grain	630	995 to 1050

Wheeler states in his report that sugar and dextrine appeared to be the most flammable of all the dusts, the temperature at which ignition could be effected being 540 deg. C., a temperature well below red heat. It is interesting to contrast this low temperature with the ignition temperatures of the gases given above, from which it will be noted that the ignition temperatures of sugar and dextrine are lower than methane, carbon monoxide and hydrogen, ranging with ethane and ethylene. Most of the remaining dusts have practically the same ignition temperature, 600 to 650 deg., thereby ranging with the other gases.

When the Federal Government began the study of dust explosions attention was directed to a determination of the ignition temperatures of the various dusts and the methods and conditions under which these dusts propagated flame. With the apparatus used in the tests, the following results were obtained:[5]

Kind of Dust	Ignition Temperature Resulting in Propagation
Wheat elevator dust	1295 C. equals 2363 F.
Flour	1265 C. equals 2300 F.
Oat and corn elevator dust	995 C. equals 1821 F.
Oat hull dust	1020 C. equals 1868 F.
Yellow corn dust	1025 C. equals 1877 F.

From the many theories which have been advanced in the effort to explain the action that takes place during the progress of dust explosions, two appear prominently: (1) That

[3]*Chem. and Met. Eng.*, Vol. 23, No. 19, 1920, p. 915.

[4]*Trans. Chem. Soc.*, Vol. 95, p. 517.

[5]Preliminary Report on the Explosibility of Grain Dusts. Cooperative Investigation by Millers Committee, Buffalo, N. Y., under the direction of Dr. George A. Hulett, chief chemist, Bureau of Mines, U. S. Department of the Interior, by David J. Price, engineer in charge, and Harold H. Brown, assistant chemist, Grain-Dust Explosion Investigations, Bureau of Chemistry, U. S. Department of Agriculture. Copies no longer obtainable.

a distillation of flammable gases occurs when the dust becomes heated, resulting in an explosion; and (2) that the explosion is nothing more than a rapid communication of flame or fire from one particle to another, depending to a large degree on the fineness of the dust. That is, the finer the dust and the lower the moisture content the more rapid the propagation and therefore the greater the violence accompanying the explosion. This would seem to establish very definitely a relation between fire and explosion.

In connection with the investigation of a large number of explosions and fires in grain threshing machines in the Pacific Northwest, the Department investigators made the following determinations:[6] In 117 cases observed 95, or about 80 per cent, were sudden, violent explosions, and the remaining 22, or 20 per cent, were merely fires. This would seem to indicate that in the majority of cases the explosions were accompanied by violence, while in the others the fire had not advanced to a point where it assumed the proportion of an explosion.

In the 95 cases referred to it was felt that the explosion might be classified either as sudden and violent, or as slight and muffled in nature. The same phenomenon has developed in connection with dust explosions in industrial plants. In many cases a primary explosion, which is nothing more than a small puff, is followed by fire in which the property is extensively damaged or destroyed. In other cases a series of explosions follows, becoming more violent as it progresses, destroying both life and property. This would seem to indicate very definitely that if the dust is present in the plant to feed the original flame, an explosion follows. In plants where little dust is in suspension and where "good housekeeping" is practiced, the occurrence merely assumes the proportions of a fire and no violent explosion results. Reference is made to this phenomenon at this time to emphasize the fact that a disastrous dust explosion may occur during the course of any fire if sufficient combustible dust is present in the plant to feed the flame and allow it to propagate. The dust that accumulates throughout the plant is thrown into suspension by slight concussion, with the result that the primary "ignition" or explosion develops into a secondary explosion of large proportions.

VELOCITY OF FLAME

Experimental work has been conducted to determine the velocity or rate of flame travel in dust explosions. It is understood that the rate of propagation or flame travel in a gas explosion depends upon two factors: (1) The flammability of the gas, and (2) the amount of gas present. For instance, the explosive limit of methane gas ranges from 5½ to 14.5 per cent,[7] with 9.6 per cent as the most flammable mixture. With this latter percentage the rate of flame travel is the most rapid and the explosion most violent. The rate of flame travel in dust explosions depends also on (1) the flammability of the dust, and (2) the amount of dust in suspension. In some of the early reports of the Bureau of Mines it is stated that the average velocity of flame in coal dust explosions is 2,270 ft. per second. British investigators report 2,114 ft. per second, while in French experiments 3,300 ft. per second has been obtained.

The maximum velocity of propagation of flame in many gaseous mixtures has been determined with accuracy. The following results have been obtained:

Gaseous Mixtures	Velocity, Feet per Second
Hydrogen, $2H_2 + O_2$	9,250
Ethane, $C_2H_4 + 3O_2$	7,724
Methane, $CH_4 + 2O_2$	7,616
Carbon monoxide, $2CO + C_2$	5,510

The velocity of propagation in explosions through most gas mixtures is more rapid than through most dust clouds, although in a few cases it has been found that the velocity of flame propagation in coal dust explosions has exceeded the maximum for certain gases. In only two tests has any attempt been made to measure the velocity of propagation of the flame in clouds of materials other than coal dust. One indicated that the velocity through a cloud of wheat flour dust was practically the same as through coal dust; the other that the propagation through a cloud of powdered starch was several times as rapid as through coal dust. The results, however, cannot be considered to be conclusive.

PRESSURES DEVELOPED BY DUST EXPLOSIONS

In connection with the determination of the ignition temperatures and the relative ease of flame propagation of dusts an effort has been made to determine the pressures developed during the progress of the explosion. In the large-scale tests that have been conducted the Bureau of Mines reports a pressure of 103 lb. per sq. in. with coal dust. British investigators report pressures ranging from 100 to 120 lb. per sq. in. Taffanel, a French investigator, reports pressures of 227 to 270 lb. per sq. in. He states that in one test at the steel gallery an established pressure strength of 227 to 270 lb. per sq. in. was maintained and that pieces of steel were thrown up a distance of 150 m., or 472 ft.

Much work to determine the relative flammability of the various dusts has been done by both the Bureau of Mines and the Bureau of Chemistry. After a series of extensive experiments the following results, based on the use of 75 mg. of dust in the standard laboratory apparatus, were obtained:[8]

Kind of Dust	Pressure Generated Lb. per Sq. In.
Lycopodium	17.5
Wheat smut dust	15.9
Yellow corn	15.2
Dextrine	14.6
Tanbark	13.3
Wheat elevator dust	13.0
Wood dust	12.8
Corn starch	12.7
Sugar	12.2
Potato flour	11.7
Fertilizer	10.5
Coal (Pittsburgh)	10.1
Cocoa	9.1
Sulphur	8.8
Cork	7.4

From these results it might be concluded that the grain dusts are more flammable than Pittsburgh standard coal dust. This has been confirmed by large-scale tests which indicate that flame propagates through a cloud of grain dust more easily and with a more violent explosion than through a corresponding amount of coal dust.

In very recent tests conducted in coöperation with the Bureau of Mines in the steel galleries at Bruceton, Pa., it was found that flour and coal dusts acted similarly. Starch dust propagated more rapidly, produced higher pressures, and did a great deal of damage to the steel galleries used in the tests.

It has already been stated that dust must be present in suspension in proper proportions before an explosion can occur. Efforts are being made in the experimental work to establish these proportions, as has already been done in connection with the gas mixtures. In some of the tests conducted results were obtained when one-twentieth grain, or 0.00176 oz., of dust was put in suspension in 1,400 cc., or 85.36 cu. in., of air. To obtain the same proportion of dust in air and render the mixture as flammable as that used in the laboratory test it would be necessary to have only 10 lb. of the dust in a closed room containing 4,446 cu. ft., or a room 10 x 30 x 15 ft.

The first dust explosion to attract attention in this country

[6] U. S. Department of Agriculture, Bulletin 379, p. 5.
[7] U. S. Bureau of Mines Technical Paper 150, p. 6.
[8] *Journal of Industrial and Engineering Chemistry*, Vol. 9, No. 3, p. 269.

occurred at Minneapolis in 1878. Professors Peck and Peckham of the University of Minnesota conducted experimental work in the investigation which followed the explosion. In this investigation it was found that by blowing 2 oz. of dust upon an open flame in a box containing 2 cu. ft. of air sufficient pressure was developed to lift two men standing on the cover.[3] This would mean diffusion at the rate of 1 oz. of dust to 1 cu. ft. of air space. Their report states that a sack of flour and 4,000 cu. ft. of air will generate force enough to throw 2,500 tons 100 ft. high.

The Bureau of Mines reports that explosions could be produced when only 0.032 oz. of coal dust was suspended in 1 cu. ft. of air, or 1 lb. in 500 cu. ft. It was found in order to produce complete combustion all the oxygen in 1 cu. ft. of air was required to burn 0.123 oz. of the dust used.

In the French experiments conducted by Taffanel an instance is cited in which the low weight of 0.023 oz. of dust per cu. ft. of space was sufficient to produce an ignition.

Experimental work is now in progress to determine definitely the smallest amount of dust in suspension per unit area through which an explosion can propagate.

RELATION OF HUMIDITY TO EXPLOSION FREQUENCY

The relation of humidity to the frequency of dust explosions has been markedly noticeable in the investigational work. This is especially true in connection with explosions where static electricity has appeared as a probable cause. In the large number of thresher explosions in the Pacific Northwest, which comprises the inter-mountain territory between the Cascade and Rocky Mountain ranges, it was found that in 128 cases 86 explosions, or 70 per cent of the total, occurred between the hours of 1 and 7 P. M., when the humidity was extremely low. The range of humidity was usually from 6 to 17 per cent. These explosions have occurred in grain separators during the threshing of wheat containing smut dust. In 112 explosions from 1 to 35 per cent of the heads of wheat being threshed were smutted. In 108 cases the average smut percentage was 15.

WIND POWER*

ON behalf of the Zionist Organization, Dr. Ing. M. Mayersohn has recently studied the wind-power problem with special regard to installations in Palestine. In his dissertation, presented to the Berlin Technical High School, he has collected a great deal of useful information on the types of wind mills used in Denmark, Germany and Holland, on experience gained with them and on the design of new installations. He makes out a better case for windmills than might be expected. He gives information on 477 installations—not ordinary grain mills. Of the 415 German mills of those tables 87 per cent had worked very satisfactorily for periods of up to eighteen years. In Denmark, the utilization of wind power has been much stimulated during the war; in several instances small communities are coöperating in supplying the local electricity works with from 20 per cent to 50 per cent of the power needed.

The favorite new wind motors for this purpose are Agricco motors, made by the firm of Hans L. Larsen, and known hence also as the Hansell motors. The Agricco wheel consists of five wings of the propeller type, made of sheet-iron, each wing turning against the action of a spring about its radial arm, to the one side of which it is attached. The older types common in Denmark are the Paul La Cour wheel—four or six arms set cross-ways with vanes of the Venetian-blind type—and the Sörensen cone motor. The six wings of this latter motor would, if placed together, make up the surface of a cone of a very obtuse apex angle; each wing is built up of curved cross-vanes. Sörensen motors have been built up to 27 m. (88 ft.) in diameter for 50 hp., but they are not so efficient as the Agricco. The old-fashioned wind roses, large wheels consisting of many radial vanes of wood, are still built in Denmark; most of the vanes we have mentioned are made of galvanized iron. More common in general are the wind turbines of the American construction, up to 5 m. in diameter, and the German wind turbines of the Herkules type, made in diameters of 15 m. (50 ft.) and even 30 m.

Some of the 477 windmills which Mayersohn inspected or about which he inquired had done thirty-five years' duty. La Cour's Askov mill works still after twenty-three years without having ever been repaired. Only six total wrecks were reported. Repairs are not infrequent, especially in some parts of Germany, where the peasants take the notice too literally that the mills require little attendance. Grease was, moreover, very scarce during the war. Trouble had also arisen because the man in charge, finding that the mill could deal with heavy loads, increased the load until the wheel could not turn and became a prey to the wind. In other cases the wheel would not come to rest, causing overflow and other disturbances. Most of the plants serve for pumping, irrigation or drainage; a few mills drive workshops directly, or propel electric machinery with or without accumulator batteries.

Small agricultural machinery can generally be fitted for wind power, without difficulty. For installations of more than moderate dimensions, however, the project should be studied as carefully as with water power. A wind velocity of 2 m. per second, which can generally be relied upon in Northern Central Europe, is sufficient to start some types of wheels, though the La Cour wheels require speeds of 5 m. But the designer has to inquire into the maxima and minima as well as into the average values. A calm of a day or two is a serious feature; longer calm periods during windy days are also to be reckoned with, and in recognition of the utility of wind power the German Meteorological Office has recently supplemented its reports so that the wind velocity can be traced through its diurnal period. Where calm days must be allowed for, the storage capacity of the plant has to be increased. At Haifa, on the coast of Northern Palestine, a good wind is blowing all the summer months, from May to October, but there are calm days in these two months, when the season changes and when irrigation is still necessary. The meteorological observations taken by the German settlers there before the war show that in 1908 there was no wind on May 17 and 18, and again on May 20 and 21, and on May 26 and May 29. To meet this trouble it is recommended that the storage capacity should be increased from two days to at least three days.

DIRECT CURRENT CONVERSION

IN the French press there appeared a description of an apparatus whose object is the simplification of methods whereby direct current can be converted from one voltage to another. It is manufactured by the Société Romain Bon of Liége and is briefly described by *Electrician* (London), as follows:

It consists of what is essentially a direct current generator, but with a fixed armature and a rotating field. Instead, however, of the usual arrangement of armature windings, what are in effect a number of series transformers are used, the terminals of which are connected to a commutator from which current can be collected by a system of revolving brushes. This arrangement in combination with the revolving field and an elliptical air gap gives an equipment whereby any desired conversion can be realized by increasing or decreasing the number of ampere turns in the stationary coils. The makers point out that as the general conditions resemble those of a static transformer a minimum of iron and copper are required, and that there are no crossing leads at different potentials, thus facilitating insulation and reducing the risk of short circuit. Commutation is said to present no difficulty, though the usual design is modified by replacing the parallel bars with an arrangement of staggered contacts. Nevertheless, as the biggest machine that has so far been built is 1 kw., it is too early to be definite on this point.

[3]*Chemical Engineer*, March, April, May, 1908.

*From *Engineering*, (London) Dec. 10, 1920, p. 769.

Thermal Conductivity of Building Materials*

Experiments Undertaken to Determine the Heat Losses of Various Structures

By C. Schroeder

THE question of conservation of heat in a building presents far more difficulties than some other problems of construction. Usually persons considering this subject content themselves with the somewhat vague declaration that insulating of "warm" walls should be employed. An opinion which rests rather upon the sense of feeling and upon "non-controllable" experience than upon exact experimental investigations, but the question is undoubtedly of peculiar and pressing importance today because of the scarcity and dearness of fuel. Obviously the more pervious to heat a wall is the greater the waste of fuel when the space enclosed by it is to be kept at a hygienic degree of temperature. . . . It is not until comparatively recent years that an effort has been made to determine these questions by scientific methods. Some time before the beginning of the Great War a start was made in this matter by the Laboratory for Technical Physics connected with the Technical High School in Munich. Assistance was lent by the coöperation of the Munich "Institute for the Study of the Economics of Heat," which was founded by industrial circles in October, 1918.

The investigations made by these bodies were based upon the following well-known facts. A source of heat of a constant strength (a stove, radiator, etc.) was used. By means of this

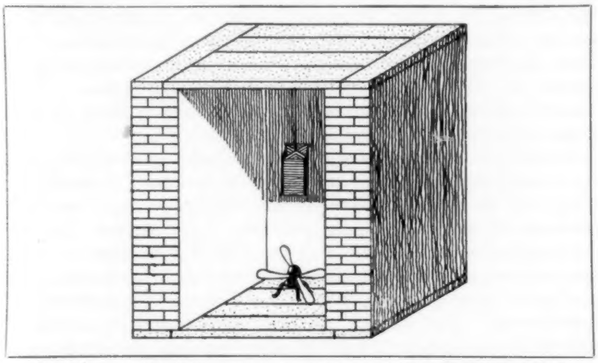


FIG. 1. EXPERIMENTAL COTTAGE FOR TESTING THE CONDUCTIVITY OF HEAT IN BUILDING MATERIALS

The hot air from the electric heater is distributed evenly by the electric fan

source of heat the air in the room is first warm and then the walls which enclose the room become heated and finally a portion of the heat which has pentrated the walls passes out into the surrounding atmosphere. There finally occurs a state of equilibrium in this process, which can be recognized by the fact that when this state is reached the same amount of heat is given off by the wall into the outer air as has been received by the inner side of the wall. . . . This passage of heat through the wall is comparable to the flowing of a fluid. The obstacles met by a stream of water can be overcome only when a certain amount of pressure or a corresponding difference in height is present, and such obstacles may be compared to the resistances (which vary according to the material) encountered by the current of heat and which the latter can overcome only by a change of temperature corresponding to the resistant object in question. Just as the water can flow more rapidly over a smooth surface so the denser the body to be penetrated the less resistance encountered by the current of heat; just as a gutter with uneven and rough walls hinders the flow of water, a loose, light, air filled material checks the flow of the current of heat.

In analogy to the laws of fluid bodies it is found that within like intervals of time the amount of the heat transmitted increases in the same ratio as the area of the surface and as the difference of temperature between the two sides of the wall, while it decreases, on the contrary, in proportion to the thickness of the wall; finally, it is in harmony with a special factor, namely, the degree of conductivity of heat for the given material. This magnitude, known as the thermal conductivity number, gives the units of heat which pass through the surface unit of the wall (1 sq. m.) in the unit of time (1 hour) when there is a difference of 1° C. between the two surfaces of a wall 1 meter thick.

These thermal conductivity figures have been determined by careful experiments with various building and insulating materials, such as common tile or brick, as also the porous and hollow variety, slag, natural stone, mortar, wood, gypsum, sheets of cork, and of peat fiber, etc. These materials were prepared in sheets having a surface extent of about ¼ of a square meter and were warmed on one side by exposure to an electric source of heat. Special care was taken to have all the heat produced pass through the material to be tested. The thermal conductivity figure was then determined after the stage of permanency was attained, by a calculation involving the factors of the given amount of heat, the surface, and the thickness of the material. These figures having been obtained it is easy to calculate the quantity of heat transmitted through any given wall composed of one or more of these substances. For example, the following figures were obtained for various walls:

1.44 cal. in a brick wall of a thickness of 1½ bricks (this may be regarded as the normal wall for dwelling houses);

1.66 cal. in a gravel cement wall, 40 cm. thick;

1.87 cal. in a limestone wall, 1½ stones thick;

2.4 cal. in a wall 50 cm. thick built of quarry stones.

On the other hand a wall made of hollow tiles, one brick thick gave the figures 1.3 calories, while still more advantageous was a well plastered wall only 1 brick thick of Rhenish porous stone in which the loss of heat was reduced to 0.77 calories; not quite so good but still excellent was a wall of the same thickness made of furnace slag which allowed the passage of about 1.15 calories.

The higher prices and scarcity of building materials have naturally led to inferior construction with a corresponding increase in the amount of heat transmitted through these poorer and thinner walls. This can be partly compensated, however, by the use of special insulating materials, such as sheets of cork, peat fiber, etc. It has been proven in fact, that this distribution of solidity and insulation among two different materials give especially good results. Thus we find that the loss of heat in a brick wall covered with a layer of insulating material 3 cm. thick reduces the loss of heat as follows:

From 1.44 to 0.78 calories in a wall 1½ bricks thick
From 2.10 to 0.92 calories in a wall 1 brick thick
From 3.85 to 1.17 calories in a wall ½ brick thick

A great many new methods of building have sprung up since the war; these mostly employ gravel cement or slag cement in combination with layers of air or hollow spaces filled with some insulating material; it is impossible to assign fixed values to the heat loss in such cases, since the thermal conductivity of cement varies greatly according to its composition, method of mixture, and density. The heat loss of a structure built with walls consisting of a 6 cm. gravel cement layer, a 12 cm. layer of air, and a 6 cm. layer of slag cement, is estimated at approximately 2 calories, but when the air space is filled with slag this value is reduced in

*Translated for the *Scientific American Monthly* from *Die Umshau* (Frankfurt), October 16, 1920.

the case of a brick wall 38 cm. thick. Prepared cement blocks which are frequently divided by air layers show a heat loss of 1.2 calories in the most favorable cases. Houses made of wood, or of wood combined with unburnt brick or slag blocks when they contain well distributed air spaces, vary in their heat law from 1.1 to 1.6 calories.

Testing Heat-loss in Experimental Houses.—For the purpose of testing heat-loss in such forms of construction under conditions approximating those encountered in actual practice, small experimental houses were built with side walls, 2 sq. meters in area (Fig. 1). These were set up in a large laboratory in order to avoid difficulties and complications due to variations in the weather outdoors. Definite forms of structure was chosen for the walls: A brick wall 1½ bricks thick, a concrete wall composed of gravel cement and slag cement, wooden walls and roofs; the floors and ceilings were constructed of an insulating material having a known thermal conductivity. The source of the heat—an electrically heated body, was placed inside each of these little houses near a fan whose purpose was to distribute the heated air evenly. The method of measuring the loss of heat was the same as in the first experiment. In this manner it was possible to make an immediate measurement of the amount of heat transmitted

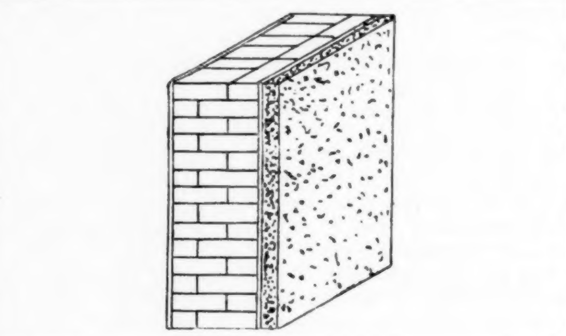


FIG. 2. WALL SHOWING AUXILIARY WALL OF KNOWN THERMAL CONDUCTIVITY IN FRONT OF IT

The heat loss in the wall being tested is found by measuring the temperature on each side of the two walls

through the wall under test. It was also possible to determine the effects produced by outside influences such as the amount and distribution of humidity, etc. The results obtained agreed admirably with the individual values previously secured. Thus, for example, the heat-loss from the brick wall 1½ bricks thick was found to be 1.43 calories. (Figures similar to those obtained by theoretical calculation.) A framework structure which was lined with boards on both sides underlaid by plaster covered boards proved excellent, with a loss of only 0.8 calories; without the underlay of plaster covered boards the heat loss amounted to 1.2 calories. In a structure composed of hollow cement blocks there was a heat loss of 2.1 calories which indicates that this form of building is of doubtful value.

In order to complete the experiments by a study of the influence exerted by *location and climate* a simple experiment was devised by means of which the conditions of the heat conductivity in the finished building can be tested in any given instance. As shown in Fig. 2, this method consists in placing in front of the wall to be tested an extra wall having a known thermal conductivity. The room is then heated by any desired source of heat and kept at as even a temperature as possible. The warmth thus produced must pass through the auxiliary wall before reaching the wall of the room. In each of the two walls a current resistance makes its appearance and, as explained, in the earlier portion of this article, this resistance can be overcome in the case of a given amount of heat only by a given difference of temperature. Consequently, the resistances exhibited to the flow of the heat correspond to the differences of temperature. Since the resistance to heat conduction of the auxiliary wall is a known quantity, it is only necessary to find the temperatures upon each side of the auxiliary wall and each side of the wall to be tested, in order to discover the amount of resistance to the conduction of heat exhibited by the latter. A simple calculation enables us to determine the quantity of heat loss from the amount of resistance displayed.

The present conditions obtaining in Germany as to supplies of coal . . . indicate the great economic importance of this question. It is to be hoped consequently that the Department of Buildings and Construction which has hitherto been concerned chiefly with the safety from fire and the solidity of buildings, will require that proper care be taken to secure the proper amount of protection against heat loss in their construction. In their own interest persons erecting buildings should demand of their architects the greatest attention to the securing of economy of fuel, while architects themselves must be advised of the necessity of enlarging their scientific equipment for the practice of their profession by a study of the technology of economy of heat.

RESEARCH IN WOOD FOR THE BUILDING INDUSTRY

FOR generations the proper size of timbers to use in wood buildings was a matter of custom. Now higher working stresses are permitted by building codes and it is possible to design more economical buildings. This is the result of increasing knowledge of the strength properties of wood. Much of the credit for making available this essential information belongs to the Forest Products Laboratory at Madison, Wisconsin. Considering its relatively meager appropriations from year to year and the financial uncertainties under which it labors, its accomplishments have been great. But the needs of further knowledge in the use of structural timbers are almost unlimited.

How shall built-up beams and columns be designed, and what are these conditions under which their use is desirable? How can structural timbers be preserved from decay and the attacks of borers? What influence have defects on the strength of columns? What stresses should be used in wood girders and trusses of 50 to 70 foot span such as are used in garages? What do we know of the strength of fastenings and joints? Has fireproofing and slow-burning construction been fully developed? What of shrinkage and the better seasoning of wood? And with carefully worked out grading rules and consequent higher working stresses why cannot the cost of wood buildings be materially reduced? The Forest Products Laboratory is seeking to solve some of these problems, but in order to do so, it needs the support of industries which will benefit by its results.

DISINTEGRATION OF ROOFING TILE

ACCORDING to J. Scott, who writes in *The British Clay Worker*, 29, 138-140 (1920), roofing tile sometimes disintegrates owing to a fungous growth, a type known as mucor racemose being especially destructive. Rain and dust settle in the pores of the tile and this becomes a foundation for the spores. A net work running through the pores of the tile is formed as the spores grow and in a few days thread-like spore-bearing stalks are sent up and these soon scatter a new lot of spores. The fungus obtains its food partly from the dust and partly from the tile and the stalks are hollow and filled with a sap traveling upward. The points of these stalks or threads yield ferments which enable them to soften and split off small particles from the tile. During the process volatile mineral matter required for the fungus is drawn from the tile leaving it more susceptible to the destructive action of thawing and freezing. Thus this natural chemical process proceeds, although slowly. Lichen, which very often covers roofing tile, is not destructive to it since it obtains its nourishment from the air.

The Welding Arc*

Is the Metal Transmitted Chiefly as a Spray or as a Vapor?

By A. W. Slocum

Professor of Physics, University of Vermont

DURING the summer of 1918 the writer was associated with the Welding Research Council. During that period he made a careful study of the Welding Arc.

Transmission of the metal in the form of vapor appeared to be the most probable hypothesis. This part of the phenomena, however, is so marked by the unavoidable spraying and spluttering of the electrode and plate that many have considered this as the essential part of the phenomena. This point of view is ably presented by Prof. R. G. Hudson of the Massachusetts Institute of Technology in his article on a theory of metallic arc welding published in the first issue of the *Journal of the American Welding Society* and republished in the SCIENTIFIC AMERICAN MONTHLY for March, 1920.

Professor Hudson says: "It would appear from the observed facts that the metal deposited during metallic arc welding is transmitted in part at least in the form of minute particles which are projected from the electrode globule by the internal expansion of some vapor, possibly carbon monoxide."

He also says: "Under the circumstances, it may be seen that the melting of the iron is delayed by the heat absorbed by the other constituents of the electrode, and that this fact together with the limited time of application of high temperature disproves the possibility that the iron is completely vaporized in the welding process."

Stated in such terms, Professor Hudson's conclusions are entirely correct. The metal is transmitted *in part* from the electrode to the plate and from the plate in all directions in the form of spray or globules. And if it is transmitted in part as spray, it is evident that it cannot be *wholly* transmitted as vapor. The question whether the chief element in the phenomenon is vaporization or gaseous propulsion is, however, still a live one. The writer has little doubt that transfer in the form of vapor will ultimately be accepted as the more probable hypothesis.

It is not a wholly new hypothesis. Frequent reference to a kind of vapor formation is made in the literature of the common arc. Such references are generally made in a suggestive rather than positive manner, but the phenomenon of the common arc is more complicated than that of the welding arc. In the common arc the vapor is not produced so rapidly as to sweep the air entirely out of the space between the electrodes. In this case the vapor which is formed from one of the electrodes largely returns and condenses on the electrode from which it comes. This phenomenon can be clearly seen with a microscope of about twenty magnifying power used to view the behavior of a small current arc. Small condensed globules of microscopic size can be seen to emerge from the core of the arc and fly in curved paths toward the respective electrodes from which they came. Some of these particles escape into the air borne along by the air currents. Some return to the electrode at a distance from the spot on which the arc is playing and there deposit as a yellow dust. Some return to the electrode close to the spot from which the arc plays and form a beautiful orange colored coral like growth. The orange deposit is magnetic, the yellow powder is not magnetic. These growths and powder deposits for arcs with different metals are described by Professor Duffield, *Phil. Mag.*, 1918.

When the current strength becomes sufficiently large to sweep the air entirely away and form a vapor core from electrode to electrode we have the "hissing" or welding arc.

It is true that the hissing arc is generally referred to as being due to the action of oxygen getting at the crater, largely on the basis of the careful experiments of Mrs. Herta Ayrton.

She showed beyond doubt that under certain conditions the addition of oxygen would cause a silent arc to become a hissing arc. She also found that a stream of hydrogen sent into an arc which was surrounded by atmospheric oxygen would cause the arc to become a hissing arc, while hydrogen sent into an arc which was surrounded by nitrogen would not cause the arc to hiss. She naturally associated hissing with the presence of oxygen, but it is clear that it might just as well be associated with the increased heating effect of oxidation and the more rapid formation of vapor to form the vapor core from electrode to electrode.

That the conditions in the arc are favorable to vapor formation is clearly shown by the results of the measurements of the electrode tips by Hagenbach and Langbein. The following paragraph is quoted from *Science Abstracts* (Section A, Physics), April, 1919:

"*Temperature of the Electrodes in the Arc.* A. Hagenbach and K. Langbein (Archives des Sciences 1. (Sec. 5), pp. 48-54, Jan.-Feb., 1919). For current densities not too small the anodes of metallic arcs (silver, copper, iron, nickel and tungsten) are heated at the tip by the current up to the temperature of ebullition, while the cathodes are heated less. If the end of the cathode is strongly oxidized and forms an oxide with a high temperature of ebullition, aluminum, zinc and magnesium) the temperature rises still higher, probably up to the temperature of ebullition of the metallic oxide. If oxidation is prevented by using an atmosphere of nitrogen, the temperature is lowered to the ebullition temperature of the metal. The temperature of the cathode is found to be the same as that of the anode in the case where metallic oxides are formed."

In the electric arc the heat that raises the temperature of the electrode tips is produced and delivered directly on the surface of the tips. The heat is produced in accordance with the law; watts equal the product of amperes (current strength) and volts (electrode fall). To liken the process to the heating of the surface of a bullet by the heat produced in the burning powder is totally to disregard the peculiarity of electrical activity.

The secret of the electrical activity of the arc lies in the electrode fall. To attempt to describe its action is a matter of extreme delicacy and great difficulty.

It is directly associated with the electric force necessary to produce thermions from the tips in sufficient quantity for the current strength. This electric force is conditioned by the temperature of the electrode tips, is affected by the presence of oxides, depends upon the material in the surface layer of the tip, is of different magnitude at the anode from that at the cathode and the force at one electrode is affected by the freedom of thermionic liberation at the other electrode. It is the intricate interrelationship of these factors that makes the arc a difficult phenomenon to examine experimentally, and also the reason why we find so much misguiding information in the assumed results of experiments. The one factor which has probably needed the closest attention, the actual state of temperature of the surface layers of the tips, has seldom received consideration. Before the days of the tungsten filament, and thermionic amplifiers and rectifiers, the importance of the temperature was not sufficiently appreciated.

For the purpose of considering the electric activity of the arc, let us take a low current arc between two welding wire electrodes 1/8 inch in diameter, and then increasing the current by steps, consider the changes that occur with each step.

*From *The Welding Engineer*, Jan., 1921.

When the arc is first struck, the electrode tips are cold, the electrode fall is very large, heat is added to the surface of the tip at a rate proportional to the product of the current strength and the electrode fall, the temperature of the tip rises very rapidly, and the electrode fall diminishes with corresponding rapidity. As the temperature rises, the conduction and radiation of heat away from the surface of the tip increases. There comes a time when the heat produced in the surface just balances the heat conducted and radiated away.

However small the current, so long as it is large enough to maintain an arc, this stage of equilibrium is not reached till the temperature has risen considerably above the melting point of the electrode, and examination with a microscope shows that the surface is vaporizing with considerable rapidity though the greater part of the vapor returns as condensed fine globules to the electrode from which it comes. When the equilibrium between the heat produced and the heat conducted and radiated away has become established, the arc burns steadily so long as the temperature of the surface of the tips, the material in the surface of the tips, and the current strength remains unchanged. A voltmeter joined to the electrodes maintains a constant reading.

If, now, we increase the current, we increase the rate of heat supply. This increases the temperature of the tips and this in turn reduces the electrode fall. Soon the equilibrium stage is reached with the electrodes at a higher temperature than in the first case, lower electrode falls and a smaller reading of the voltmeter across the arc.

When we increase the current to about 8 or 9 amperes, the surface of the anode reaches the boiling point, the electrodes splutter and molten drops fall from the tips. Thus it takes 8 or 9 amperes for a 1/8 inch electrode to supply the heat conducted and radiated away when the temperature of the tip is at the boiling point.

With a current in excess of about 10 amperes, an arc between two welding wire electrodes of 1/8 inch diameter blows up with excessive spluttering. With a 1/8 inch welding wire as one electrode and a plate to be welded for the other electrode, the arc burns without too excessive spluttering with 150 or even 175 amperes flowing.

This leads us to an interesting question which pertains to the welding arc alone. What influence on the welding wire can the plate have to increase the current capacity of the wire from 10 to 150 amperes? Alternating current behaves in this respect as direct current. The phenomenon is then one that depends upon the square or some even power of the current. This consideration limits the phenomenon to one of heat effect. We have, therefore, only two hypotheses to consider: the heat effect in the propulsive expansion or formation of gases, and the heat effect in the production of vapor of the material of the surface of the tip.

For the propulsive expansion or chemical formation of propulsive gases in the interior of the electrode, the heat must be conducted inward from the surface to the interior of the electrode. It is difficult to see how the presence of the plate as opposing electrode can affect this rate of conduction inward so as to reduce it to 1/15 of its value when another wire instead of the plate is the opposing electrode. On the hypothesis of the boiling from the surface of the electrode, it is easy to see that the presence of the plate will produce precisely such a result. Not only this, but it is also easy to see how too strong a current produces a cutting arc rather than a welding arc.

When the vapor formation becomes sufficiently rapid to maintain a tube of vapor from electrode to electrode from which the air is completely expelled, then the arc is behaving precisely like a steam heating plant. The boiling of the surface of the electrode into vapor absorbs latent heat. The condensation of the vapor on the welding plate sets free the latent heat to be conducted away by the plate. The vapor condensing on the plate raises its temperature to the boiling point and we then have the plate in condition for its maximum rate of heat conductance and the voltage drop across the arc at its lowest possible value. Further increase of current strength has no effect upon the voltmeter reading across the arc so long as the material of the surface layers of the tip and plate remain unchanged, but it does begin to boil away the surface of the plate, boiling faster and faster as the current gets stronger and stronger and, in some cases, forming a blast of vapor strong enough to cause a deposit of material at a distance of one or two inches from the spot on which the arc is playing and a still stronger current cuts a hole in the plate immediately under the arc.

On the vapor hypothesis, so long as the current strength is suitable for welding, the amount of metal deposited is proportional to the excess of current above that necessary to keep the temperature of the electrode tip at its boiling point.

On the vapor hypothesis, the maximum current that can be advantageously used in a given case is limited by the heat conductance of the welding plate.

On the vapor hypothesis, the rule is suggested of choosing a current strength suited to the maximum heat conductance of the plate, and use the smallest wire electrode that will handle the current.

In the writer's limited experience with welding during the summer of 1918, these rules seemed to be justified, though often other factors such as an unusual amount of spluttering of the electrode appeared to mask them.

The vapor hypothesis or the gaseous propulsive hypothesis alone cannot furnish a complete theory of the arc behavior. For this purpose, we need a study of the electrode falls and such a study takes us beyond the field of welding.

It is, however, very important for welders to note some of the peculiarities of the arc behavior and the electrode falls.

The arc consists of two electric streams flowing in opposite directions. Increase the intensity of one of the streams and for a given current strength, the other stream diminishes in intensity. Interrupt either stream and the arc goes out.

In very low current arcs, 1/10 ampere or less, the temperatures of the tips are relatively low, and the cathode fall is higher than the anode fall, and the cathode surface becomes hotter than the anode surface. In the case of currents above about one ampere, this is reversed and the temperature of the anode becomes hotter than that of the cathode.

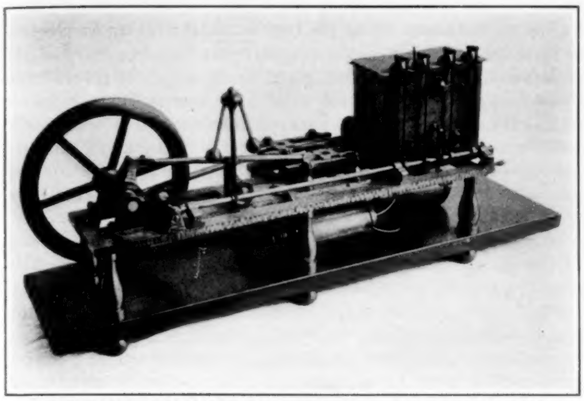
It is easier to start an arc from a cold spot on an anode than from a cold spot on the cathode. The arc is stable with one cathode and two anodes, but it is unstable with one anode and two cathodes. These are the reasons why the wire should be made the cathode in welding. The arc creeps along the cold plate better when it is made the anode.

In conclusion, it seems apparent that the vapor hypothesis of metal transfer deserves the careful consideration of experimenters with the welding arc, that the formation of propulsive gases or vapors of constituents of lower boiling points deserves careful study for their proper control, and that the interpretation of experimental results needs a careful application of the principles of heat, electricity and chemistry. Until we are able to apply these principles simultaneously and harmoniously, we cannot have a satisfactory theory of the welding arc.

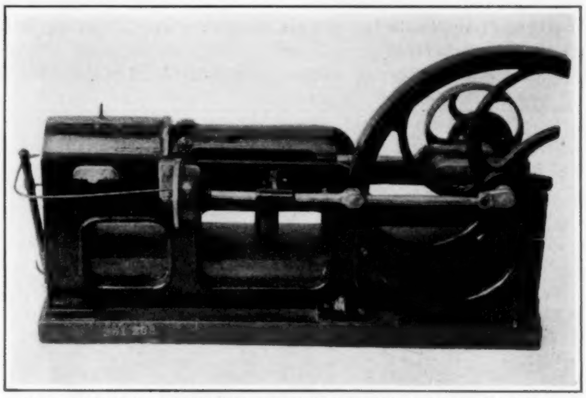
FUEL OIL FROM MAIZE

The germ of this cereal contains approximately 12½ per cent of oil and a special process involving heating with petrol has been developed for its extraction.

It is considered an important one in Serbia and Roumania, where large quantities of maize are available, as, owing to the present scarcity of natural fat, the oil is used for the preparation of fatty substitutes and commands a remunerative price. A factory in Belgrade produces half a ton of oil daily, and other factories are being built. The oil is not suitable for lubrication on account of its resinous nature, but is a good fuel oil.—G. Goldberg, *Feuerungstechnik*, Sept. 1, 1920. Abstracted by *The Technical Review*.



INTERNAL COMBUSTION INVENTED BY PERRY, 1846
The fuel used was the vapor of spirits of turpentine fed by compressed air



OIL ENGINE INVENTED BY ERRANI AND ANDERS, 1873
The first internal combustion engine for which oil was the stipulated fuel

Ancestors of the Liberty Motor

Origin and Development of the Internal Combustion Engine

By Carl W. Mitman
Curator of the U. S. National Museum

Illustrations from Collections in the Department of Arts and Industries, U. S. National Museum

THE earliest internal combustion engine was the gun and assuming that the gun originated with the invention of gunpowder, which has been known in the East from times of dimmest antiquity, it may be inferred that the Liberty motor has quite a pedigree. The use of gunpowder, however, as a means of obtaining mechanical power is of comparatively recent date, such experiments having been made during the latter part of the 17th century by Hautefeuille, Huygens and Papin. Huygens in 1678-1679 exploded a charge of gunpowder in the bottom of a vertical cylinder. The greater part of the air and of the gaseous products were expelled through non-return valves, but the remaining gases, in cooling, produced a partial vacuum below a piston which then descended owing to the atmospheric pressure on the outside and in so doing did work by means of a cord over a pulley.

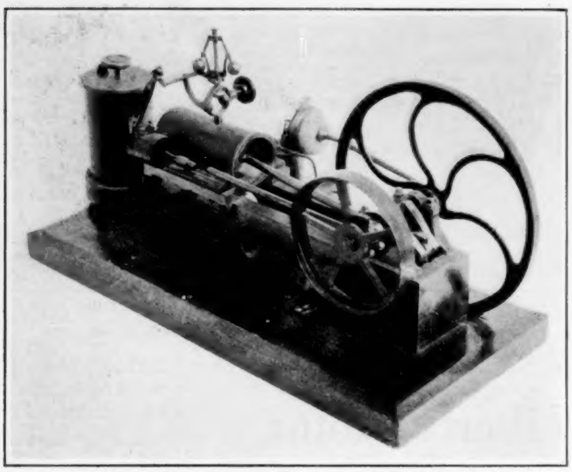
A period of over a hundred years ensued before any further experiments were made utilizing the explosion of inflammable gases. In 1794 an English inventor, R. Street, secured a patent, No. 1983, which involved the vaporizing of spirits of turpentine on a heated metal surface, mixing the vapor thus produced with air in a cylinder, firing the mixture by an outside flame, and driving a piston by the explosion produced. Another fifty years passed when in 1844, one Stuart Perry, of New York, procured a United States patent for "An engine to be operated by the explosive mixtures of inflammable gases or vapors." Two years later a second patent, No. 4800, was granted to Perry for improvements made on the original engine which were embodied in a model submitted at the time of the request for a patent, and which is illustrated here. The rectangular box to the right is a metal tank filled with water and containing the cylinder and a retort in which gas is generated. (Although the patent claimed the use of any inflammable gas or vapor, the inventor vaporized spirits of turpentine.) The cylindrical tanks beneath the engine bed contain air under pressure, filled at first by a hand pump but, after the engine is in motion, by a pump operated by the engine, a portion of which may be seen on the far side of the machine. To operate the engine, it is first necessary to heat the water in the tank by some outside means, in order to vaporize the turpentine. Gas having been generated, the extraneous supply of heat is removed and air from the tanks is admitted into a valve-box located above the retort. Through a slide valve some of this air enters the retort, is mixed with the gas, and exits through suitable apertures to passages leading to opposite ends of the cylinder. The admission of the gas to the cylinder through these intakes is controlled by valves operated by rods (to be seen on the outside of the tank) which in turn are operated by appropriate cams on a shaft receiving motion from the crankshaft. The two inside rods control the exhaust valves, the exhaust being in the under side of the cylinder.

The opening of an intake valve permits the gas to pass along the intake passage to the cylinder. At one point in its travel the gas passes over a hot platinum cup, previously heated by the burning of a portion of the gas obtained through a by-pass from the valve-box. The red-hot platinum ignites the gas and the resultant expansion forces the piston to the opposite end of the cylinder. Upon reaching the end of the stroke, the intake valve at this end of the cylinder opens, admits gas which is similarly ignited and forces the piston back. Such is the cycle. The water in the tank serves a variety of purposes; it keeps the engine cylinder sufficiently cool for efficient operation; its temperature, however, is sufficiently high to vaporize the turpentine; and it lubricates the piston rod and prevents it from being overheated. Another interesting feature of this engine was the firing of the charge of gas by heated platinum rather than a naked flame as practiced by earlier inventors.

Nothing startling came of this engine and another period of 30 years passed before the next improvement of the oil engine came about. During this time, however, the first practical gas engine was developed in France by J. J. E. Lenoir and patented in 1860. Although it did not embody any new features it was successful. To start the engine, the flywheel was pulled over, thus moving the piston which drew into the cylinder a mixture of gas and air through half its stroke. The gas was then exploded by an electric spark, which moved the piston to the end of its stroke, the pressure meanwhile falling, by cooling and expansion to that of the atmosphere when exhaust took place. In the return stroke the process was repeated, thus resembling a double acting steam engine, and having a one-stroke cycle. The engine was water cooled. The electric spark was supplied by two Bunsen

batteries and an induction coil, the circuit being completed at the correct intervals by contact pieces on an insulating disk on the crankshaft.

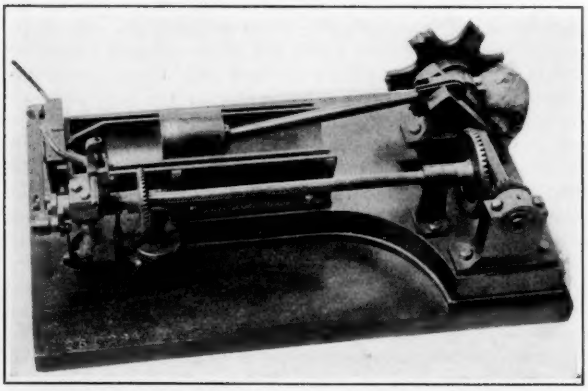
To get back to the oil engine. On June 17, 1873, a United



OIL ENGINE INVENTED BY J. HOCK, AUSTRIA, 1874
The first practical successful oil engine of the non-compression type

States patent was issued jointly to L. C. Errani and R. Anders for new improvements in dynamic machines which the inventors called "a motor without gas." A photographic copy of the model submitted with the request for a patent is reproduced here. The invention is of interest in that petroleum (presumably the lighter oils) is stipulated and used for the propelling force. The motor is in general similar to an ordinary steam engine including a cylinder, reciprocating piston, crank and flywheel and valve-gear for operating, through a cam, a main valve connected with the cylinder.

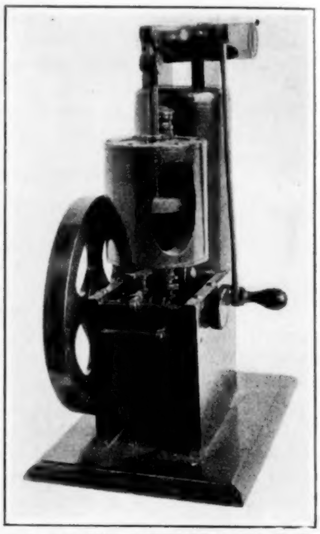
Instead of being actuated by steam, however, it is actuated by the expansive force resulting from the ignition, at the beginning of the "outstroke," of a mixture of petroleum and air sprayed into the cylinder through an aperture in its head. The oil spraying device operates on the same principle as that of the household atomizer and cologne spray. Beneath the engine is an oil tank, from the bottom of which protrudes a vertical tube. This is surrounded by an air chamber whose



GAS ENGINE INVENTED BY N. A. OTTO, GERMANY, 1877
The first type of engine in which the explosive mixture was first compressed before firing. Also the first practical application of the four-cycle stroke. The invention revolutionized the internal combustion engine industry and founded the automotive industry

upper end terminates in a nozzle opposite the aperture in the cylinder head. Blasts of air obtained from a rubber bulb intermittently compressed by the action of a plunger operated by a crank on the main shaft, fill the air chamber, forcing the oil up the tube and out of the nozzle together with air into the engine cylinder. Upon the ignition of the oil by an electric spark, expansion moves the piston forward to the end of its stroke, and the impetus thus given to the flywheel returns the piston to its normal position ready for a repetition of operations. The quantity of oil sprayed into the cylinder is regulated by a cock in the charging pipe of the oil tank. When this cock is open, all of the air forced into the air chamber by the bulb compressor passes out of the oil tank through the cock and exerts no pressure on the oil which therefore cannot rise to the nozzle and the engine stops.

Less than a year after Errani and Anders received their patent, a patent was granted to J. Hock of Vienna, Austria, patent number 151129, May 19, 1874, for improvements on the Errani and Anders motor, which improvements resulted in the making of the first practically successful oil engine. A photographic copy of a model of this engine is reproduced here. Oil is supplied to the motor from an air-tight tank, the quantity being regulated by raising or lowering a plunger immersed in the oil. The cylinder end of this oil supply pipe is nozzle-shaped and is screwed into the cylinder head. Arranged in the cylinder head are one or more air nozzles directed across the path of the oil and supplied with air from a bulb similar to that of the Errani and Anders motor. The mixture of oil and air is ignited by a flame of gas directed horizontally into the cylinder through a hole in its head. The gas which is naphtha is obtained from a generator attached to the bulb compressor which generator consists of a tank containing petroleum. Air from the compressor is forced through the petroleum, yielding a mixture of naphtha and carbonized air. A portion of this gas passes directly to the engine cylinder, at intervals, and the balance is stored in a tank to supply a gas burner whose flame is in the path of the petroleum igniting gas and ignites it as it passes into the cylinder.



OIL ENGINE INVENTED BY G. B. BRAYTON, BOSTON, 1874
The earliest compression engine using oil as fuel

The engine cycle is as follows:

The gas burner is lighted and the flywheel turned. During the forward motion of the engine piston a small amount of petroleum is admitted and atomized by air. After the piston has moved a quarter stroke the air bulb is compressed, causing a blast of carbonized air and gas to be emitted from the generator. The mixture exits through a nozzle, is immediately ignited by the flame of the gas burner, proceeds into the cylinder and ignites the petroleum vapor within. The pressure created by the resulting combustion closes all valves and forces the piston forward to the end of its stroke and the impetus of the flywheel bring the piston back ready for the next charge.

The gas and oil engines developed up to this time were of the non-compression type. They were likewise heavy and awkward and gave little power. But, about the time that Hock obtained his patent, G. B. Brayton of Boston, Mass., obtained a patent, No. 151468, June 2, 1874, for an oil engine which worked on a constant pressure but without any explosion. This appears to be the earliest compression engine to use oil. A photographic copy of a model of this engine is shown here. The engine consists of a vertical cylinder,

single acting. On the crankshaft are two cams which operate the intake and exhaust valves located in the cylinder head. To the rear of the engine proper is an air tank with air under pressure as great as 60 pounds per square inch, maintained by the engine itself. A suitable valve regulates the amount of air passing out of the tank to the intake pipe. Surrounding the intake is an annular space stuffed with some absorbent material which is saturated at each revolution with a prescribed quantity of oil, the saturation being accomplished by a suction and force pump (to be seen on the engine bed) operated by a cam and connecting rod on the main shaft.

Above the intake pipe and the surrounding annular chamber is a circular opening in which is placed a wire gauze diaphragm, on the upper surface of which gas is constantly burning, the gas being supplied from an outside source.

To operate the engine the gas above the wire diaphragm is ignited, and the intake valve opened. Air from the tank enters the intake pipe and in passing upward permeates the absorbent material charged with oil through holes in the walls of the intake pipe. The oil now vaporized and mixed with air continues upward, passes through the wire gauze diaphragm and is ignited. The resultant expansion moves the piston upward and the impetus of the flywheel returns it. Should the temperature of the air be too low to vaporize the oil, its pressure is sufficient to drive the oil out of the absorbent in the form of a fine spray which upon striking the wire gauze diaphragm is instantly vaporized, mixes with air and is ignited as under normal conditions.

This brings us to the time when probably the greatest improvement in the internal combustion engine was made—namely, the compression of the explosive mixture in the engine cylinder before ignition and the introduction of a practical engine working on the four-cycle stroke. Both of these steps were made by N. A. Otto of Germany and patented in the United States August 14, 1877, patent No., 194047. The compression of the explosive was Otto's idea but the four-cycle stroke, it is now conceded, was proposed by A. Beau de Rochas of France in a treatise published in 1862, but it remained for Otto to develop it practically. By this system a much more diluted mixture could be fired than formerly, giving a more quiet explosion and a more sustained pressure during the working stroke, while, as the engine ran at a high speed, the flywheel action was generally sufficient to correct the fluctuations caused by there being but one explosion for four strokes of the piston. Although Otto developed and patented his ideas to apply to the gas engine, the advantages were soon recognized and almost immediately applied to the oil engine and are still so applied, further improvements being mainly in the direction of higher compression.

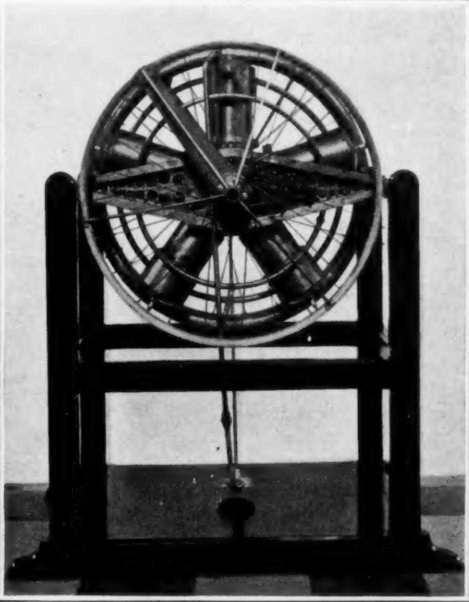
The illustration here shown is a copy of the sectional model submitted by Otto when he applied for patent rights. The engine is single acting, having a water jacketed cylinder. The piston having completed its "instroke" and about to be moved through its "outstroke" by the momentum of the flywheel, a slide valve opens to admit air. As the stroke proceeds, the air supply is cut off, and the combustible gas intimately mixed with air is drawn in until the piston has arrived at the end of its "outstroke." The gas port then closes and the piston is caused by the impetus of the flywheel to perform its "instroke," when the charge of gas and air that filled the cylinder is compressed and at about the time for the beginning of the second "outstroke," the gas is ignited, and the gradual expansion of the gases causes the piston to complete this stroke. The second "instroke" then expels the products of combustion through an exhaust valve. A fresh cycle commences on the next "outstroke."

The gas and air are admitted by a slide valve which serves also as an igniting valve, carrying a pocket of flame from an external light to a small port. The exhaust valve is of the drop type and is placed at the side of the cylinder. Both valves are actuated by a shaft driven by gearing at one-half the speed of the crankshaft. The speed of the engine is regulated by a centrifugal governor which when the normal speed is exceeded prevents the admission of gas.

Shortly after the introduction of the Otto gas engine, a motor of this type was brought out operated by an inflammable vapor produced by passing air on its way to the cylinder through the light oil known as gasoline. A further supply of gasoline was subsequently drawn into the cylinder to form the required explosive mixture which was then compressed and

AUTOMOBILE DESIGNED AND CONSTRUCTED BY CHARLES E. DURYEA BETWEEN 1892 AND 1893, THE SECOND MACHINE MADE BY HIM

The single cylinder gasoline engine also designed by Duryea is equipped with a "floatless" carburetor which by hand manipulation fixed the speed of the engine. There is no engine control from the driver's seat



GASOLINE ENGINE OF THE LANGLEY AERODROME, 1903

The lightest engine for its power built up to that time. Five stationary steel cylinders, water cooled. Horsepower, 52; weight, 115 pounds

fired. The Spiel petroleum engine followed and was the first Otto cycle motor which dispensed with an independent vaporizing apparatus. A light oil, of a specific gravity of not over 0.725, was injected directly into the cylinder on the suction stroke by means of a force pump. Upon entering it formed a spray, was mixed with air, vaporized, compressed and ignited as in the gas engine.

Up until 1883 the oil engines produced were heavy and cumbrous, rotating at a speed of between 150 and 250 revolutions per minute. Gottlieb Daimler, however, about this time conceived the idea of a small oil engine with light moving parts and to run at a speed of 800 to 1,000 revolutions per minute. In 1886 he made his first experiment with a motor bicycle and on March 4, 1887, ran, for the first time, a motor car propelled by a gasoline engine. While the motors developed by Daimler contained nothing new in their cycles of operation, great credit must be given him for realizing the possibility of producing durable and effective engines rotating at high speeds and for providing the first step in gasoline motive power development.

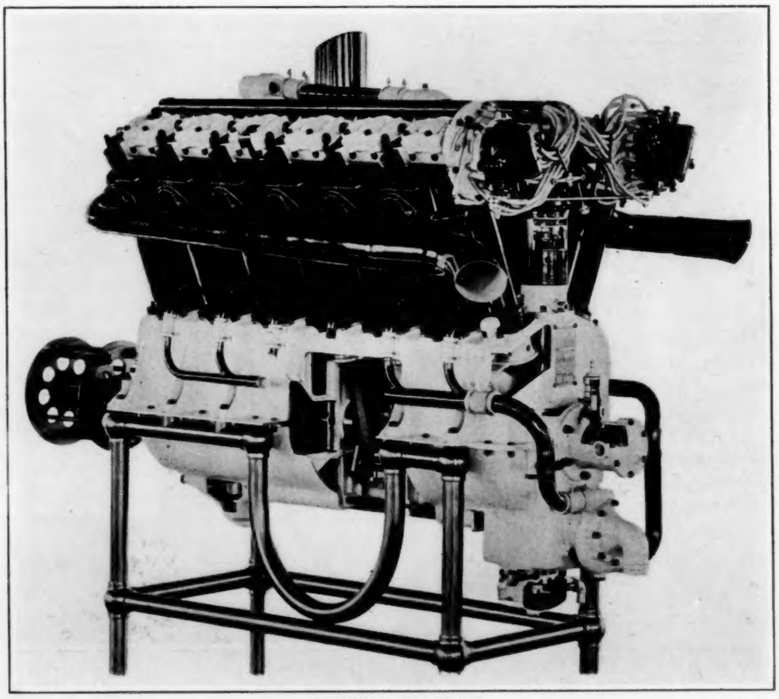
The date of the successful trial of Daimler's motor car marks the time of the divergence of the almost parallel paths of progress of the gas and oil engine; the gas engine continuing as an agent of power primarily for industrial use and the oil or gasoline engine branching off and advancing particularly as a motive power agent along which line it has made its greatest progress.

The possibilities of the gasoline engine brought to light by Daimler were almost immediately taken up and developed in Europe and the United States especially by Benz in Germany; by Panhard, Levassor, Peugeot, de Dion, Delahaye and Renault in France; by Napier, Lanchester, Royce and Austin in England; and by Duryea Brothers, Haynes, Apperson, Olds, Winton, and others in the United States.

The progress made since then in the development of the gasoline engine is far beyond the scope of this article, except in so far as examples may be given to visualize it. Thus, the Duryea Brothers when building their first "horseless carriage" in 1891-1892 had available for use the Daimler motors but, considering these far too heavy and cumbrous, they designed one of their own which was much lighter in weight and gave efficient service. A somewhat heavier one was designed for their second machine, reproduced here, which likewise was successful. This engine is equipped with a carbureting device on the order of a modern carburetor minus the float. Ignition of the "make and brake" type was used. Throttle control of the engine was thought impossible so that the engine ran at a constant speed (on the level).

When in 1900 Professor Langley of the Smithsonian Institution endeavored to procure a gasoline engine to propel his man-carrying aerodrome, such engine to develop a great amount of power but be light in weight, no builders could be found to undertake the work. An engine therefore was designed and built in the Smithsonian Institution shops under Professor Langley's direction, a photograph of which is reproduced here. The five cylinders are seamless steel shells, lined with cast-iron liners one-sixteenth of an inch thick shrunk into them. The combustion chambers entering the side of each cylinder near the top were machined out of solid steel forgings and secured to the cylinders by brazing. The cylinders are stationary and the piston rods are connected to the crank which operates a central main shaft. At a speed of 550 revolutions per minute the engine developed 52 horsepower. The entire power plant including cooling water, carburetors, batteries, etc., weighs less than 5 pounds to the horsepower. While this engine proved to be one of the lightest for its power ever made, its record did not hold for any considerable length of time for progress in design of gasoline engines did not stop there, but was ever moving forward. As evidence of this and as an indication of present day achievements contrast the Langley engine with the 1920 Liberty engine, the product of the best minds and skill in the whole American automotive industry—a twelve all-steel cylinder engine, having a 5-inch bore and 7-inch stroke, giving a total piston displacement of 1,650 cubic inches which develops 420 horsepower at 1,700 revolutions per minute and whose total weight is but 885 pounds.

The ancestry of the Liberty motor is thus established. Her direct genealogical tree, however, while not very old, say 225 years, is not of the conventional shape but more that of a tree whose growth for 190 years has been upward as a trunk but from which in the last 30 years have sprung many branches which recently have been joined together by their tips to form a pinnacle—the Liberty Motor.



LIBERTY-12, 1920
All steel cylinders: 5-inch bore, 7-inch stroke. Horsepower, 420 at 1,700 R.P.M. Weight, 885 pounds

ROAD SHOCKS AND RUBBER TIRES

WRITING in *Auto-Technik* (Nov. 6, 1920), A. G. von Loewe criticizes the efforts made to discover a solution of the problem of absorption of road shocks by substitues for rubber, and proves by means of calculations and analysis of stresses, that all designs, which rely upon springing without resiliency, must fail.

He endeavors to calculate the enormous stresses which a pneumatic tire must endure, and classifies them according to their direction as radial, tangential and transverse. When an obstacle is encountered by a car traveling at, say, 40 miles per hour, it produced a hanmer blow, part of which is transmitted to the springs, but most of the force must be absorbed by the resiliency of the tire else the vehicle will be smashed.

The stress set up by application of the brakes can be determined.

Producing Heat by Catalysis*

Flameless Stove Used by the French Army During the War

By R. Villers

IN 1817 Humphrey Davy succeeded for the first time in making a lamp without a flame. A spiral-shaped piece of platinum previously heated and then placed in a mixture of air and combustible gas, hydrogen or carbon-monoxide remains incandescent while the mixture is kept up, producing water vapor and carbon dioxide without alteration of the platinum. This reaction, which was purely experimental at that period, is today an inexhaustible source of new processes. The phenomenon of catalysis, in short, had been discovered! While catalytic action is applied in industry in the most multifarious manner, it has remained one of those phenomena as yet unexplained and to elucidate which many hypotheses are suggested. For the purposes of the present brief article we shall content ourselves with the following definition: The phenomenon of catalysis consists in the splitting up or the combination of one or more substances under the influence of some specific substance which itself takes no part in the reaction.

Silver in a pulverulent form, for example, decomposes hydrogen peroxide without itself undergoing alteration; aniline is produced by the mixture of hydrogen and nitrobenzine in the presence of platinum black; another application of catalytic action is the manufacture of sulphuric acid by what is known as the contact process.

These phenomena have been particularly studied by the French scientist, P. Sabatier, Dean of the University of Toulouse, and winner of the Nobel prize. But one of the most ingenious applications of this principle which has ever been made is the utilization not of the chemical phenomenon, properly so called, but of the heat emitted by the chemical reaction.

The apparatus invented for this purpose owes its origin, like so many other devices, to the war. As early as the winter of 1914-1915 our aviation service met with many annoying mishaps and disappointments because of the fact that when the order was given to make a reconnoitering flight the radiators had either been emptied to keep them from freezing or else their water was too cold to allow the motor to start; in either case time was lost with all that that implies in a state of war. It was necessary, therefore, to avoid such annoyances by finding some way to keep the water and the oil at a temperature sufficiently high to allow the machine to start at the first revolution of the propeller. This has to be done, moreover, without the use of a flame, in order to avoid the risk of setting fire to the highly inflammable plane, and without the use of substances which might be injurious to the crew or staff.

This very delicate problem was solved by Messrs. Louis Lumière and J. Herck by the creation of various catalytic heating apparatus whose use since the war has become quite general for heating purposes in situations where there is danger of fire or of explosion.

These apparatus, which have been patented by the inventors, make use of gasoline, which is decomposed by means of catalysis into water vapor and carbon dioxide through platinum in the presence of air.

In the diagram shown in Fig. 1, A represents an asbestos mat impregnated with platinum and serving as a top to B which has the form of the frustrum of an inverted cone. The member B rests upon another cone frustrum C, which forms the top of a reservoir D.

This reservoir is filled with a spongy substance, a sort of fleecy cotton, which absorbs the gasoline poured in and thus avoids there being an excess of liquid. A wick E extends into this reservoir; evaporation takes place from this wick in the chamber formed by the upper cone and mat.

The reaction continues automatically after having been started by a previous heating of the asbestos mat, which thereafter furnishes a heating surface having a temperature of 250° C. (482° F.); the action continues so long as the reservoir B has any gasoline left in it.

As for the previous heating of the asbestos mat this is easily accomplished by pouring a few drops of gasoline or alcohol upon it and setting fire to them; or by an electric resistance; or by means of a carburated gas obtained by using a bicycle pump, for example, to blow air through the opening employed to fill the tank, then lighting this gas above the mat.

It is evident that there is absolutely no danger connected with the use of this device, since during its operation it not only has no flame and no incandescent portion but it gives off absolutely no odor and no injurious by-product.

The work done is the maximum possible since the gasoline is entirely decomposed, developing the entire amount (about

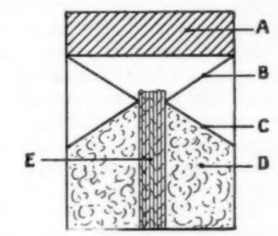


FIG. 1. DIAGRAMMATIC VIEW OF THE CATALYTIC HEATER

11,000 calories), of heat representing its theoretic calorific power.

A number of highly practical pieces of apparatus operating on this principle are on the market under the general trade name *Thermix*.

One type which was used by the army during the war is meant to be placed, in cold weather, within the hoods of automobiles, etc., to avoid the necessity of emptying the water from the radiator, and to keep the lubricating oil in a fluid condition so as to facilitate starting the engine. Other types are meant for the heating of rooms as an auxiliary to the usual apparatus, stoves, radiators, etc., and not to take their place. These thermix stoves, for instance, can be used in the spring or the fall to warm up a chilly room, when only a few degrees of heat are necessary to make it comfortable. One of these consumes 60 grams of fuel per hour with a heating capacity of 30 cubic meters; the other uses 120 grams per hour with a heating capacity of 60 cubic meters.

Small pocket stoves and muff stoves are made upon the same principle and will run for eight hours with a fuel consumption of 1 gram per hour; these may also be employed to exhale perfume if a few drops of the latter be previously scattered upon the wick.

It is a simple matter to extinguish the apparatus. All that is necessary for this purpose is to cut off the air supply from the catalytic mat by means of the cover provided therefor.

It is quite evident that these thermix apparatus are very practical and that they can be made use of for many purposes other than those mentioned above; while as they become better known these heating apparatus at once economical, portable, and non-dangerous, will doubtless be more widely employed.

*Translated for the *Scientific American Monthly* from *La Nature* (Paris), December 25, 1920.

Gasoline by the Charcoal Absorption Process*

Description of the Activated Charcoal Process of Absorbing Vapors from Natural Gas

By G. A. Burrell, G. G. Oberfell and C. L. Voress

TWO methods of extracting gasoline from natural gas—compression and oil absorption—are now used extensively, while refrigeration is used to a limited extent. The charcoal process, a recent development operating on entirely new and scientific principles, compares most favorably with either of these methods. It produces higher yields and a better grade of gasoline. It does not require heavy initial installation costs and can be operated more cheaply. The apparatus has longer life and is not subjected to inefficiency due to wear. Its adaptability to field conditions is enhanced by the fact that it operates on either lean or rich gas at either high or low pressures.

This year there will be practically 300,000,000 gallons of gasoline produced from natural gas. Where the salable vapors in the gas are over a gallon per thousand cubic feet, it is possible to recover a considerable proportion by directly compressing and cooling the entire volume of gas. Where the salable vapors in the gas are not so plentiful, it has been the custom to resort to the oil absorption process, which is simply a method whereby the desirable vapors are concentrated by partial fractionation so that pressure and cooling may be effectively applied as in the original compression process. The gas is made to bubble or flow through absorbers where the gas comes in contact with a high-boiling mineral oil or naphtha which absorbs the heavier fractions in excess of the lighter ones. The oil or naphtha is then subjected to steam or direct heat to vaporize again the absorbed fractions so that they may later be condensed by cooling and compression.

DISADVANTAGES OF THE COMPRESSION AND ABSORPTION PROCESSES

There are several features of the present processes which are considered obnoxious by practical operators.

Both the oil absorption and compression systems require considerable pressure. The oil absorption may be used at low pressures, but it is not considered good practice because of the low saturations which must be adhered to. These high pressures are not only expensive to produce but mean large outlays for repairs and renewal of machinery. They also increase the danger of explosions.

Quite a little difficulty is experienced in marketing the product because of the large amount of so-called "wild" vapors which it contains. These vapors are the lower boiling fractions which have been absorbed and condensed in the higher boiling fractions by the compression, cooling and solvent action of the liquid. It has been apparent to many men for some time that a method whereby a sharp fractionation could be obtained would eliminate much of this trouble. Methods of hot blending and steam treatment have been used with varying success as a substitute for the original fractionation, but all admit that there is still much room for improvement.

The present oil plants are far from simple both in number of units and operation. Constant supervision is necessary if the oil plant is to be operated at as high a degree of efficiency as 75 per cent of gasoline extraction.

From the standpoint of pressures used, of quality of product, of efficiency of extraction, of simplicity of apparatus and operation, and of cost, a new process, one working on an entirely new principle, has been demanded.

CHARCOAL ABSORPTION PROCESS

The charcoal absorption process consists of bringing the natural gas into intimate contact with activated charcoal, in the capillaries of which the vapors are condensed and the dried gas allowed to return to the distribution lines. When a predetermined saturation of absorbed vapors has been attained in the charcoal, the gas is allowed to come into contact with a fresh supply of carbon. The vapors retained in the first mass of charcoal are then evacuated by distilling off with superheated steam, condensed in water-cooled condensers, blended and stored preparatory to marketing. Fig. 1 is a flow sheet diagram of the plant.

ACTIVATED CHARCOAL

The charcoal best suited for the successful operation of the process is made from cocoanut shells by the steam activation process developed during and since the war. Charcoals made by other methods do not possess sufficient absorptivity to pay for the costs of recovery and therefore are of no use in this process.

One very essential feature that the charcoal must possess is what we term selective absorption. Natural gas consists of the gases and vapors of the paraffin hydrocarbon series, the higher members of which have an appreciable vapor pressure at the temperature of the gas. When the gas is first brought

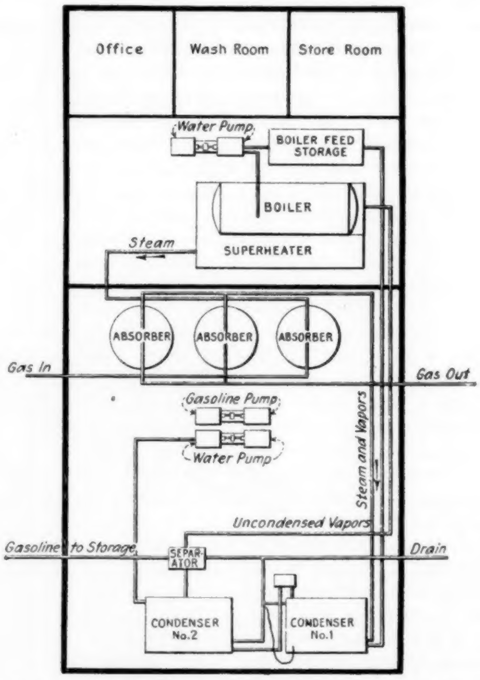


FIG. 1. FLOW SHEET DIAGRAM OF THE PLANT

into contact with the charcoal the lighter, high-volatile vapors, such as ethane, propane, butane, etc., are absorbed in the capillaries, but as the saturation increases a selection or equilibrium adjustment takes place with the result that these high vapor pressure and undesirable fractions are left in the gas. The heavier fractions are thus isolated and can then be condensed after steam distillation without the use of high pressures. Regulation of the vapor tension of the final product is thus obtained by preventing the absorption of the higher boiling fractions.

The size of the granules of charcoal should be from 8 to 14

*Reprinted and somewhat abridged from *Chemical and Metallurgical Engineering*, Jan. 26, 1921, pp. 156-160.

mesh. Smaller mesh material has slightly greater absorbing qualities, but the resistance to the gas passage rapidly increases as the size of the granules decreases. Gas flowing through a column of charcoal 5 ft. in depth at the rate of 40 cu. ft. per hr. per sq. in. of base surface and flowing against atmospheric pressure will show a retardation of from 1 to 2 lb. due to the charcoal resistance.

ABSORPTION

When natural gas first comes into contact with charcoal considerable heat is developed, which is the latent heat of vaporization from the condensing vapors. After a few minutes the temperature stops rising, which indicates that selection is taking place and the heat of condensation is being used to re-volatilize the highest condensed liquids, which must be eliminated from the final product. Many investigators have ignored this phenomenon, and have stopped when no more heat evolution was noticeable, thinking that the absorption was complete. With gas rich in vapors we have observed a temperature increase of 60 deg. C. in the charcoal due to the latent heat in condensation. This does not mean that the entire body of charcoal increased 60 deg. simultaneously. The heated volume travels in a zone in the direction in which the gas flows. When using a tube of charcoal ¼ in. in diameter and 1 ft. in depth and passing rich gas at the rate of 10 ft. per hr., the heated zone is about 2 in. in depth.

The temperature of the charcoal at the beginning of the gas passage is not very important when using gas of low gasoline content. It quickly gains the temperature of the incoming gas. A loss of about 6 per cent in final recovery was experienced when tests were run with the initial temperature of the charcoal 300 deg. C. However, the temperature of the inflowing gas is more important. The curve of recoverable efficiency is practically a straight line function of the temperature, other things being constant. This curve reaches its zenith at 300 deg. C. Above that there is no recovery at all.

The rate at which absorption takes place varies according to the richness of the gas mixture. For gas yielding 400 gallons of gasoline per million cubic feet, a rate of 40 cu. ft. per sq. in. of base surface in a 5-ft. column of charcoal is not too high a rate. Above this rate the back pressure due to the resistance of the charcoal itself begins to enter as a factor against higher rates.

The volume of gas to be passed is determined by the nature of the product desired by the operator. If he desires a very volatile product, a low saturation of the charcoal must be had so as not to allow selection to eliminate too much butane, etc. If a staple low volatile product is desired, more gas is passed and the selection is carried as far as desired.

DISTILLATION

After absorption has been completed, it is necessary to expel the condensed vapors from the charcoal. This is done by blowing superheated steam directly through the charcoal. The superheat should be as high as local conditions will allow. There will be a decrease in fuel used per gallon of gasoline recovered, as the temperature of the superheated steam is increased up to the point where the radiation factor of the carrying lines and the efficiency factor of the heater itself become so large as to interfere. Local conditions affect this to a great extent. It will be found, however, that under ordinary conditions 250 deg. C. may be maintained with good results.

The amount of steam required depends upon the percentage of the available heat that is utilized. The charcoal must be heated to 200 deg. C. to dispel the heavier fractions of gasoline. This temperature also insures an active absorbent. The work done is mainly derived from the superheat. Calculations show that theoretically there are about 5,343 B.t.u. of heat required to produce a gallon of gasoline when the saturation is 13 per cent.

The question is repeatedly asked, "Does this steam distillation injure the charcoal for the other absorptions?" The steam distillation does not injure the absorptive capacity. In fact, it leaves it in a somewhat better condition than dry heating would. The steam drives out gases and absorbed vapors at a somewhat higher temperature than will permit condensation. The first rush of cooling gas will displace the steam and the first condensation will be of the vapors in the gas.

CONDENSATION

The gasoline vapors driven from the absorber with the steam may be condensed in any type of condenser. We prefer two water-cooled condensers in series. The cooling water around the first condenser can be circulated just swiftly enough to condense the major portion of steam and allow for its being trapped away without being cooled much under 100 deg. C. In many localities this condenser may well be an air condenser with enough of the line jacketed to heat the boiler feed water.

The second condenser must be an efficient one. With cooling water at 15 deg. C. or thereabout very efficient condensation will take place at atmospheric pressure.

The condensed gasoline and water flows from the condenser into a separating tank. If it is desired to blend the final product with heavier naphtha to reduce its vapor pressure, that may also be done at this point. We prefer to blend with from 10 to 15 per cent of about 56 deg. B. naphtha.

An examination of the gasoline produced has brought to light the fact that the gravity and vapor tension of this gasoline is less than the gravity and vapor tension of that made from the same gas by either compression or oil absorption. Fig. 2 is a set of curves illustrating this point. There are several reasons for this. Conditions under which the condensation is made affect the character of the final condensate. It has already been noted that the charcoal process gasoline is condensed from a vapor-gas system under atmospheric pressure. This is in direct contrast to the methods of condensation

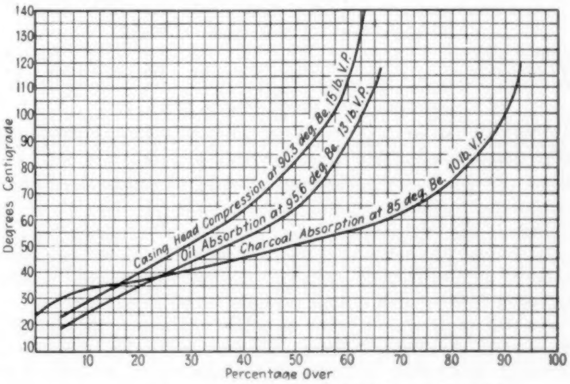


FIG. 2. COMPARISON OF GASOLINE PRODUCTS

used in the compression of oil absorption processes, where the pressure generally ranges between 90 and 250 lb. When these gasolines are placed in storage or released from compression, evaporation begins to take place immediately and desirable fractions of the gasoline are carried away mechanically with the escaping undesirable wild vapors.

The method by which the condensation is carried on is also an important factor in determining the character of the condensate. The charcoal process is a batch process. Consecutive distillations of a series of absorbers are made rather than continuous distillations of a single still. This drives out the lighter vapors first and makes possible the addition of the blending naphtha to the fraction that actually needs blending. If there are any very volatile vapors left in the charcoal, they are driven out first by the lowest temperature and do not come into contact with the salable gasoline. By the oil absorption method, which is a continuous process, all

fractions are driven out and carried to the compressors together. Here the salable vapors are condensed in the presence of the very volatile vapors under pressure, so that all the salable liquid must be saturated with wild vapors at the temperature and pressure used.

A third explanation for the better quality is found in the method of absorption itself. We have already mentioned selective absorption, which gives clear-cut fractionation controlled by the operator. The wild vapors are practically all re-evaporated into the gas within the absorber itself, thus preventing their presence in the steam distilled vapors and condensate later on.

Experience has shown that the product from charcoal absorption plants has 3 lb. less vapor tension and 10 deg. less gravity than gasoline made by an oil absorption plant operating the same gas.

Referring to Fig. 2, we see the results of applying the standard Bureau of Mines distillation test to the gasoline produced by the different methods. The initial boiling point of both compression and oil absorption gasoline is from 5 to 10 deg. below the initial boiling point of the charcoal gasoline. The final boiling points and the residue are practically the same. The curves of these distillations show that the big gain in yield is in the recovery of that product boiling between 30 and 70 deg. C., or within the range of the pentanes and hexanes. About 73 per cent of the charcoal absorption gasoline is within this class. Approximately 33 per cent of the compression and 38 per cent of the oil absorption are condensed between these temperatures.

The same series of tests showed that 93 per cent of the charcoal absorption gasoline is recondensed after the standard Bureau of Mines distillation and approximately 66 per cent of the oil absorption and 63 per cent of the compression material were recovered. None of these samples had been blended before it was tested. The oil absorption sample had been made under a final pressure of 90 lb.

TABLE I. WEATHERING TESTS

I—First Pair. Air Temperature 65 Deg. F.

Time in hours	0	1	2	4	5	18	22
Oil absorption	1,000	995	970	950	940	856	850
Charcoal absorption	1,000	1,000	998	993	990	930	925

II—Second Pair. Air Temperature 65 Deg. F.

Time in hours	0	1	2	4	5	18	22
Oil absorption	1,000	994	968	950	938	854	847
Charcoal absorption	1,000	1,000	998	994	990	930	927

III—Third Pair. Air Temperature 80 Deg. F.

Time in hours	0	2	3	4	5	9	22	25
Oil absorption	1,000	965	945	935	922	890	830	828
Charcoal absorption	1,000	995	988	982	977	960	900	898

The weathering losses of gasoline made by the charcoal process are very light. Table I shows three pairs of weathering tests, comparing samples of gasoline taken directly from the blender of a charcoal plant and gasoline taken from the storage tanks of an oil absorption plant, where it has been allowed to weather under about 3 lb. pressure for more than two weeks. All samples were blended with 12½ per cent naphtha, 56 deg. B. Each pair was kept under the same atmospheric and temperature conditions.

After what has been said about quality, the reader may infer that the yield is being sacrificed. Such is not the case. A direct comparison between an oil plant and a charcoal plant operating on very lean gas showed that the oil plant averaged around 125 gal. per million cu. ft. of gas and had a weathering loss of 20 to 30 gal. before shipment. The charcoal plant produced an average of 203 gal. of high quality gasoline from this same gas on the same days. The reasons for this wide variation between the two plants are numerous. The problem of bringing every particle of gas into intimate contact with oil capable of absorbing the commercial vapors has always been difficult. Many kinds of baffles and sprays have been tried with varying degrees of success. With an absorber packed with from 8- to 14-mesh charcoal there is no difficulty in getting proper contact for complete extraction of gas.

The absorption of the vapors by a solid medium is governed by conditions entirely different from those governing the absorption by a liquid which depends on reduction of molecular area of the dissolved vapor. It is the capillaries of the charcoal which alter the vapor tension of the absorbed paraffine and make the absorption possible. The degree to which the capillaries are deepened and oxidized free from interfering compounds determines the absorptive capacity of any particular charcoal. However, difference in grades of carbon or any other substance which might be used for the framework of these capillaries is an important factor which must not be overlooked when studying the conditions governing the absorption of gasoline.

The absorption process is actually a modification of the compression process, which consists of concentrating the recoverable vapors before applying the compression. But by the compression method it is possible to condense only a certain part of each fraction included in the gas. This part is determined by the number of fractions present, by the percentage of the different fractions present and by the temperature and pressure employed. It is only a specific application of the partial pressure laws. The addition of air or any gas not condensible at the working pressures means loss in efficiency.

HAY CAKE—A NEW FODDER FOR CATTLE AND HORSES

FROM time immemorial it has been customary to prepare winter fodder for cattle and horses, by cutting and drying the grass of their pasture to form hay. Of recent years this ration has been supplemented, not only by dried grain, such as oats and corn, but by various sorts of "cake" such as cottonseed oil cake, etc.

A recent observer, Mr. Gain, has conceived the idea that it would be advantageous to prepare hay in a similar form instead of feeding it to the animals in dry wisps, as is usually done. in a report to the French Academy of Agriculture he described the processes through which the hay must pass in order to prepare it in the aforesaid form.

Physical Treatment.—The hay must first be chopped and sifted and then passed over an electro-magnet to remove particles of metal. In this condition it may be fed to horses, mixed with crushed oats.

The cake thus produced may be partially cooked at a temperature of 60° C.

Chemical and Biological Treatment.—In a good specimen of hay the ratio between the nitrogenous and the non-nitrogenous elements is at 1 : 8. But there are certain kinds of hay which are poor in liguminous substances and which have been grown upon acid soil which have only from 1/10 to 1/13 of the nitrogenous element, and which are even poorer in fatty substances.

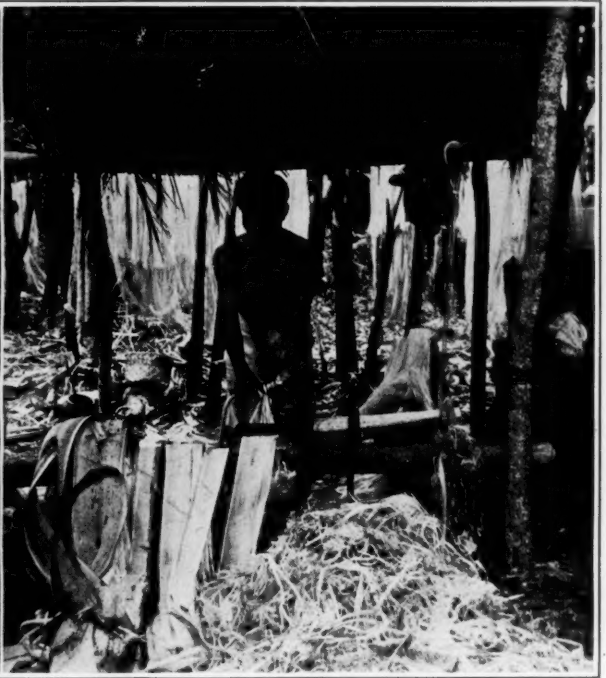
Mr. Gain experimented with the *Juncus silvatiuas*. He incorporated with the cake made of the chopped hay the dried blossoms contained in the litter laid down for the animals.

The application of a fermentation process is chiefly of use for partially attacking the indigestible cellulose. For this purpose he made use of the floral bacteria contained in the contents of the paunches of slaughtered cattle. He also made use of steam in an autoclave for modifying the cellulose.

In brief, therefore, the preparation of the hay cake requires chopping, compressing and sometimes boiling in fermentation.

The question resolved itself largely into one of economy under given conditions, but the last mentioned process, the so-called biological treatment by means of fermentation is worthy of special attention, since but little mechanical energy is required for such a treatment, and the resulting byproducts are small in amount as compared with the bulk of the fodder produced.

STRIPPING THE BARK OFF THE ABACA TREE AND CARRYING IT TO THE FACTORY



PRIMITIVE METHOD OF SHREDDING THE LEAF STALKS AND SCRAPING OFF THE PULPY MATTER

Manila Hemp

Primitive Methods of Obtaining Hemp from the Wild Banana Plant

By S. G. Williams

Photographs Copyright by Keystone View Co.

"IN union there is strength" is, perhaps, no more beautifully typified than in those combinations of fibers ranging all the way from twine to the greatest of sturdy towing hawsers. By the skilful assembling and disposition of really delicate filaments, our manufacturers of ropes produce a variety of commodities capable of meeting service stresses measuring many hundreds of tons. How little most of us know about this industrial art that plays so prime a part in endless directions in the daily life of America's multitudinous activities.

Thousands of years ago, primitive man realized that he needed pliant lengths of materials with which he might pull and bind; and in the days when hieroglyphics served to record the high spots of ancient civilization the scribe pictured for the ages to come how it was possible to fashion the fibers available into ropes strong enough to handle the massive rocky units with which the pyramids were built. The peoples of succeeding eras have, in the main, elaborated upon the principles then employed and have gradually evolved mechanical agencies designed to work faster and upon a scale quite out of the question where manual dexterity was the sole reliance. No country has achieved more in this direction than the United States; and infinite skill, inventiveness, and engineering cunning have put us at the forefront in this department of endeavor.

In the days of the sailing ship, rope figured more conspicuously aboard every floating craft; and anyone at all familiar with maritime matters was alive to the multiple ends served by hempen cordage of all kinds. Fiber rope then was inseparably and peculiarly associated with the needs of the seafaring fraternity. In the popular mind, that was the period when rope was in its preëminence; and there is a widespread and mistaken belief that with the shift from belching canvas to steam for propulsion the demand for cordage dwindled. It is a matter of fact that our consumption today is vastly more extensive than it ever was before, all because of the diversified uses which have developed latterly for cord, twine, and rope of well-nigh endless sorts. The manufacturer's problem now is not so much one of mechanical facilities as it is that of an abundance of the raw stuffs which are able to meet the standards imposed. Life, property, and the successful execution of hundreds of thousands of tasks depend upon the way in which cordage stands up to its work when the load is applied. It has been said that the world at large needs fully twice as much fiber as is at present brought to the far-flung markets, and for that reason experts are searching everywhere for new fibers susceptible of adaptation.

In the rope-making industry there are now commonly employed but three vegetable fibers, and these, named in the order of their importance and service value, are Manila hemp, sisal, and jute. A further classification places hemp and sisal in one group, *i.e.*, that of the hard fibers, while jute is designated as a soft fiber. However, there are soft hemps, such as those grown in sections of this country and abroad in Russia and Italy. These fibers are not deemed of sufficient strength to warrant making them up into any but

A NATIVE MACHINE FOR STRIPPING THE LEAF STALKS

NATIVES BRINGING BALES OF HEMP TO MARKET

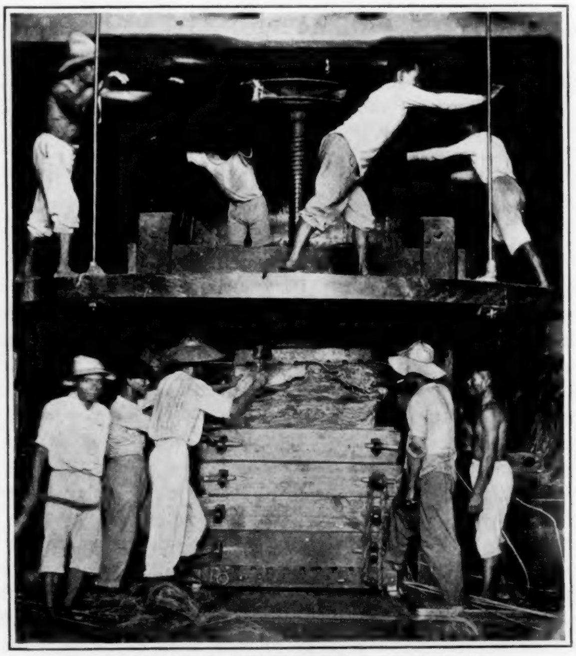
the smaller runs of cordage. The prime hard hemp comes to us well-nigh exclusively from the Philippines where there are under cultivation quite 1,236,000 acres of this particular species of the wild banana plant, botanically known as the *abaca*. While the fibers of this hemp are weak when stressed laterally still the filaments are very strong longitudinally. Repeated tests reveal that the best Manila fiber has a tensile strength of 30,000 pounds per square inch of section. And to add to the fitness of the material for the manufacture of the finest and heaviest cordage, the filaments have an average length of from 6 to 10 feet. This permits the fibers to be intimately twisted and united with a minimum of separate elements in a given measure of rope.

The abaca grows in dense masses to a height of from 15 to 25 feet, thanks to a soil of volcanic origin and the abundant rainfall of our far-eastern possessions, and reaches the cutting stage in something like 14 months. The plants reach the most favorable condition for yielding fiber just before they reach the flowering stage. The plant is then cut down and the leaf stalks that sheath the central peduncle are stripped off. It is from these leaf stalks that the fibers are obtained.

In Europe and America, the native-grown hemps are subjected to a retting process, akin to that resorted to in the case of flax, by which the pulpy substance is got rid of by mild putrefaction without harming the hair-like fibers. But in the Philippines, the manual skill of the natives is relied upon to effect the separation, and the cheapness of labor makes this commercially practicable.

The strips of leaf stalks are laid aside in the shade to dry for two or three days after which without any further preparation they are ready to be scraped. The scraping process removes the pulpy matter and leaves only the fiber.

As shown in our photographs the natives use a rude homemade stripping apparatus built out of materials at hand. This apparatus consists essentially of a block of wood and a knife between which the leaf stalks are drawn. The handle of the knife is fulcrumed close to the block and its outer end is tied to a bamboo pole which serves as a spring to hold the knife down on the block with a considerable, though resilient, pressure. By means of a foot pedal, also connected with the knife handle, the operator can raise the knife against the tension of the bamboo pole so as to permit of introducing the leaf stalk under the knife. Some of these native stripping machines are very ingeniously contrived.



BALING THE HEMP WITH A FOUR-MAN BALING PRESS

The operator uses a small piece of bamboo as a hand hold around which the end of the leaf stalk is twisted and then draws the leaf stalks between knife and block. Repeated scraping removes the cellular matter around the fibers so effectually that no further treatment is necessary other than to hang up the hemp to dry.

About 25 pounds of fiber, cut and scraped, represents a day's work of two men and it takes about three thousand plants to produce a ton of fiber. Al-

CLEANING THE HEMP BY DRAWING IT OVER POINTED SPIKES WHICH PULL OUT DIRT AND SHORT FIBERS

WINDING UP THE FIBER ON SPOOLS FOR USE IN MAKING FINE FABRICS FOR WHICH THE NATIVES ARE FAMED

though efforts have been made to introduce power driven machinery for stripping the fibers, they have not been successful particularly in view of the low cost of labor in the Philippines, and the native with his crude stripping apparatus has not yet materially felt the competition of modern mechanical progress.

The hanks are made ready for export by packing in bales weighing generally 270 pounds. Before baling, however, the material is graded by experts of long experience; and there are thirty-odd grades of the fiber used in the production of cordage. This indicates how necessary it is to choose with the utmost care the hemp designed for different kinds of rope. The relative value of the hemp is contingent upon the way the stripping and cleaning are done; and the primary strength of the fiber is the result of the age of the plant.

The native method of cleaning the hemp is to drag it across a set of spikes which comb out the dirt and short fibers. The natives twist the fiber into rope yarn and make the yarn into rope. The finest fibers are used in native looms to make delicate textiles. The fibers are not spun or twisted but are gummed or knotted at the ends. Fine gauzes and veils are made of this material, also light crapes and fabrics which are much prized as articles of dress because of their lightness and durability.

Not only is the hemp graded before it is bought and shipped from the Philippines, but it is inspected thoroughly after it reaches the rope manufacturer in this country. Here, the hanks are assorted according to their length, texture, tensile strength, and color by men long familiar with handling the raw commodity and equally at home with every stage of its preparation into cordage. Hemp of a marked whiteness and silky luster is at a premium, and is fashioned into the very finest of high-priced rope to meet a market demanding both superior appearance and endurance.

PRIMITIVE ROPE-MAKING IN THE PHILIPPINES

POISON FOR RODENTS

A FAIR variety of chemicals enters into the campaign against rodents which has sprung up in different parts of the world. In Australia tens of thousands of rodents have been killed with phosphorus. In Japan and the Philippines white arsenic has been used exclusively against rats, and lead arsenate has been used with good results elsewhere. It has been found that where strychnine can be safely used it is to be preferred to other poisons for field use. About buildings barium carbonate has given excellent results and is to be recommended, because it is comparatively harmless to domestic animals. The *London Times* states that experiments at the Zoölogical Gardens in London have disclosed the fact that from 10 to 15 grains of barium carbonate was harmless to a chicken and find a hundred grains produced no ill effects in the case of a duck. Rats, however, are killed by as little as one and a half to two grains.

The poisons commonly used are arsenic, strychnine, phosphorus and barium. Corrosive sublimate and cyanide are not recommended as rodent poisons. Many recipes for rat poison contain more than one poison, but it is now recognized that a bait in which a single poison is used is generally superior to one in which two or more have been included. Where powders are to be employed a satisfactory formula is flour containing about 10 per cent of powdered strychnine to which saccharine can be added.

Seeing Submerged Objects

Augmenting the Visual Power of Field Glasses by the Use of Analyzers

THE possibility of improving the visual power of field glasses, etc., by the employment of so-called "analyzers of light" is interestingly discussed in the *Official Bulletin of the French Bureau of Research and Invention* (Paris) for Feb., 1920, by M. Henri Bénard, under the title "Utility of Polarized Light in Observations Made at Sea and on the Seashore by Means of Field Glasses Equipped with Polarizers." We are indebted for the following abstract of this paper to the *Revue Scientifique*, Sept. 25, 1920.

On Dec. 2, 1835, Arago presented to the Bureau of Longitude an instrument composed of a tube and a piece of tourmaline with the statement that the latter substance "eliminates the light reflected from the surface of the water and enables the observer, consequently, to perceive objects lying at the bottom of the water." He also described the operation of the device in the following words: "Let us suppose that the line of vision is inclined to the surface of the sea at an angle of 37°. The light which is reflected at this angle to the external surface of the water is completely polarized. As all physicists know, polarized light refuses to traverse suitably situated slices of tourmaline. Hence such a slice of tourmaline is capable of totally eliminating the rays reflected by the water which were mingled, in the direction of the line of vision, with the light proceeding from the object under water, either eliminating them entirely or at least greatly weakening them.

"When this effect is produced the eye placed behind the slice of crystal receives, therefore, only one sort of rays—those coming from the objects under water; instead of two superposed images upon the retina there is only a single image and this, of course, considerably enhances the visibility of the object observed.

"The absolute elimination of the light reflected from the surface of the sea is possible only with an angle of 37°, since it is with this angle alone that polarization is complete; however, with angles 10° or 12° greater or less than 37°, the number of polarized rays contained in the beam of light reflected, (the number of rays which can be stopped by the tourmaline) is still so considerable that its use as a means of observation ought to give excellent results."

In accordance with the laws just stated Arago suggested a series of experiments to be made at sea with respect to the visibility of the rocks and reefs. Something like a hundred years later M. Henri Benard has been conducting experiments similar to those suggested with respect to the visibility, not merely of rocky reefs, but also of all submerged objects and especially of submarines.

It is a matter of regret that M. Benard was either ignorant of this previous work done by Arago, or else did not see fit to mention it; nevertheless he undoubtedly deserves credit for calling attention anew to the possible utilization of well-known phenomena in practical apparatus.

He begins his remark by recalling that the two luminous depths, the sky and the sea, against which the objects which one observes upon the seashore or during an ocean voyage stand out, are both more or less completely polarized, especially in fine weather (much less so in cloudy weather) while the reflection from the surface of the sea is also polarized when it is present. But if we now provide the instrument used to make our observations with an analyzer whose plane of polarization can be revolved at will, the observer will find himself able to regulate at pleasure between two definite limits the intensity of the luminous depth, against which the remote objects to be observed are delineated—in other words, he finds himself able to create or modify for the better photometric contrasts.

Of all the white objects which may be observed by analyzed light that which exhibits the most exaggerated contrast is the foam on the surface of the water whether due to the breaking surf or the passage of a boat.

The objects named below are also considerably improved in visibility especially when the sun is in the same direction from them as the observer; light colored sails of boats; seashells or muddy deposits of light color; persons in boats (provided their faces, hands, and garments are light in color); and white plumes of smoke from the funnels of steamships; and along the shore, houses, walls, forts, dykes, rocks, etc.

Improved Color Perception.—This so-called analyzed light likewise considerably enhances the perceptibility of colors in the objects sighted at sea. In this case the gain in the degree of perceptibility is really surprising—whereas ordinarily it is a well-known fact that it is difficult to discern the true shades of objects seen at sea, we find by the use of these analyzers that vari-colored muds exhibit their natural vivid coloring, and all the various colors in the bands upon smoke stacks, the clothing of men and women, etc., etc., instantly appear in the field of the spyglass as soon as the analyzer is so placed as to extinguish the reflection from the sea.

It must be admitted that there are also cases in which the visibility is diminished. Dark objects, for example, such as rocks, earth, and black-painted boats, stand out very clearly against the light, silvery gray background and gain nothing, on the contrary, when the analyzer is revolved, so that the background becomes black or dark bottle green. But even in this case it is advisable to examine the object after it has been located with the extinguishing analyzer, even if only to study the details under different shade of color. It is necessary, obviously, that the analyzer be capable of being revolved successively into the two positions.

The two methods of observation complement each other, giving the observer the exact amount of information, since it is evidently quite possible that there may be within the field of the glass both light-colored objects which are practically invisible upon a sea of shining silver, and dark or black objects which canont be discerned upon a dark green background.

Devices Employed in Practice.—In conclusion we may state the best conditions in practice for adapting various analyzers to prismatic field glasses.

Reflection polarizers consisting of two black glass sides placed parallel in order to bring the direction of the line of vision back to its initial direction should be eliminated, since they allow only a very small amount of incidental light to pass through, and the same thing is true of a single black glass as well as of a total reflection prism.

Absorption polarizers such as tourmaline, which extinguish one of the two rays due to the double refraction consist of colored crystals, which, when employed in suitable thickness absorb a large part of the vibrations which traverse them. But for many uses the green or pink color of tourmaline would be very annoying, since it would involve the relinquishment of one of the principal benefits to be gained, namely, the exact determination of colors. On the other hand the use of a very thin slice of tourmaline, which can be readily shifted, reduces to a minimum the required modification of field glasses and spectacles already in the observer's possession. The use of such a thin slice would be indicated, if one desired merely to diminish or suppress the sparkling brilliance of the reflection of the sun upon the water.

Analogous properties to those of tourmaline are possessed by an interesting artificial, dichroic crystal—*iodo-sulphate of quinine* or *herapathite* if it be employed in extremely thin layers. By transmitted light a layer of herapathite is a light violet gray in color, a shade which modifies but slightly the objects observed. Unfortunately, the preparation of lamillæ of herapathite is a very delicate matter.

By refracted prisms of Iceland spar, rendered achromatic by means of a crown prism or a simple slice of the spar having parallel faces, are not capable of sufficiently separating the ordinary and extraordinary rays. We are reduced, therefore, to the employment of assemblages of prisms of Iceland spar, such as the Nicol (a slice of Canadian balsam) or the Foucault (a stratum of air) so arranged as to eliminate one of the two rays by total reflection. The analyzer may be so placed between the eye-piece and the eye of the observer as to modify but slightly the construction and optical properties of a prismatic field glass. M. Benard gives a description of the manner in which he modified, so as to permit vision by analyzed light, the ordinary field glass constructed by Jules Huet et Cie.

The only obstacle to the general user of such devices—but a pretty serious one—is the scarcity of Iceland spar whose known deposits throughout the world are so limited in extent that they ought to be reserved as far as possible for purely scientific purposes. A technical and scientific problem, whose solution would be of great importance, would be the discovery of an analyzer as efficacious as a Nicol prism, but less costly.

Taking Photographs in Relief*

Louis Lumière's New Process of Photo-Stereo-Synthesis

At the meeting of the French Academy of Sciences held November 8th, M. Louis Lumière made an important communication to the assembled savants concerning a new method by which he has been able to take photographs of "solids in space," i.e., photographs which indicate three dimensions instead of two in the manner of a relief map or of image in a stereoscope. We give below the essential elements of the method employed with diagrams of the apparatus.—EDITOR.

WHEN upon a fixed scale photographic negatives are taken of a series of parallel planes (whether they be equidistant or not) of an object, each image representing, of course, only the intersection of the object by the corresponding plane, it is possible to reconstitute, in space by superposing the positives of the said negatives, the actual appearance of the object photographed. To achieve this it is only necessary that the distances of the positive images shall be equal to that of the photographic planes affected by a coefficient corresponding to the scale adopted.

To obtain such a reconstitution which would be theoretically perfect we should have to superpose an infinite number of images infinitely near to each other. This condition obviously cannot be realized in practice, but M. Lumière has shown by experiments that it is not necessary to do this in order to give the eye impression of continuity, and that comparatively few elements will suffice provided that within a certain limit each image shall correspond, not to a plane (which is furthermore an impossible condition) but to a given focal volume. This focal volume must, of course, be small enough to avoid the effects of parallax beyond vision.

If the experimenter attempts to secure this by means of the greatest comparative aperture at present attainable, he will find that the depth of the field is still too great by far. To obtain the required reduction of focal volume M. Lumière has devised two methods based upon the following principles:

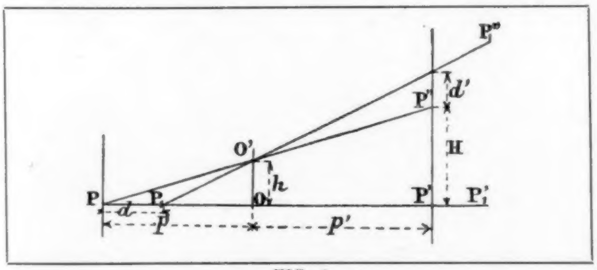


FIG. 1

1. Let O (Fig. 1) represent a lens with a plane field giving an image P′ of the point P situated upon the principal axis. If the lens be moved through a distance h so that its axis remains parallel to itself and that its principal planes are held motionless in space, the image P′ will fall at P″ situated in the conjugated image plane of the object plane containing the point P.

If, at the same time, the operator causes the image plane to move, in the same direction and without rotation upon itself through a distance H so that we obtain the equation $\frac{h}{H} = \frac{p}{p + p'}$ then the position of the image of the point P will not have changed with respect to the limits of this plane. The same thing will be true of all other points situated in the conjugated plane of the image plane.

Thus we shall have no points such as P_1 situated on this side or on that side of the object plane. To each distance d of this plane there will correspond a displacement d' of the corresponding tracing of the secondary axis upon the image plane and the value of d' will be given by the equation

$$d' = \frac{hp'}{p - d} - (H - h)$$

The image of the point P_1 will, therefore, leave upon the sensitive surface a tracing of the length d'.

2. In the second method (Fig. 2) let O be a lens provided with an inverting prism and giving the image P′ of the point

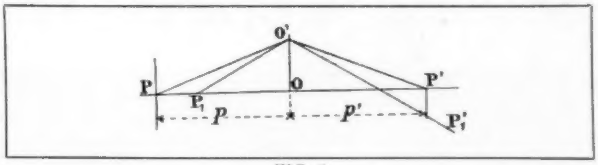


FIG. 2

P, p and p′ being necessarily equal taking into account the elongation resulting from the interposition of the prism.

If this lens be made to undergo a displacement of any amplitude whatever in the plane of the principal section of the prism and this plane, as well as the principal planes of the lens, remains invariable in space, then the position P′ of the image of the point P will not have changed. On the other hand the image of every point situated on one side or on the other of the object plane will undergo displacement in accordance with the equation given above. It will suffice, therefore, in order to reduce the focal volume to provide the lens with two inverting prisms whose principal sections shall be placed at 90 degrees from each other and to displace the axis of the lens parallel to itself, taking care to keep the principal sections likewise parallel to themselves during the displacement.

As a result of this arrangement it becomes possible to take a photograph of a surface of any extent whatever by means of a lens having any focus whatever.

For example, one which is very small with respect to the dimension of the surface photograph.

In order to apply these principles M. Lumière first constructed an apparatus satisfying the conditions set forth in the description of the second method, but since this did not give perfect results because of the lack of prisms cut in the proper manner, he then constructed the apparatus shown in Fig. 3, which satisfies the conditions set forth in the first method. Two vertical frames connected by cross-pieces (not shown in the drawing) provide bearings for four shafts *A*, *B*, *C* and *D*. There is a crank arm on each end of the

*Translated for the *Scientific American Monthly* from an abstract published in *Le Genie Civil* (Paris) for Dec. 4, 1920.

shafts and each arm carries a stud. The ratio of the length of the worward arms to the rear arms is equal to $\frac{p}{p+p'}$.

The forward studs enter sockets in the front board of the camera and the rear studs similarly support the back of the camera. The front board and the back are connected by the usual bellows. One of the shafts carries a pulley by which it is possible to rotate the entire system during the time of exposure.

It is evident from the principles above elucidated that every point situated outside the conjugated object plane of the image plane corresponding to the given ratio $\frac{p}{p}$ will produce upon the sensitive plate a circular tracing, the magnitude of whose diameter will be in direct proportion to the distance of the given point from the object plane. Furthermore the circle of diffusion corresponding to the orifice of the lens is also a factor in the disturbing of the *definition* at this point. Only those points which are situated in the conjugated image plane

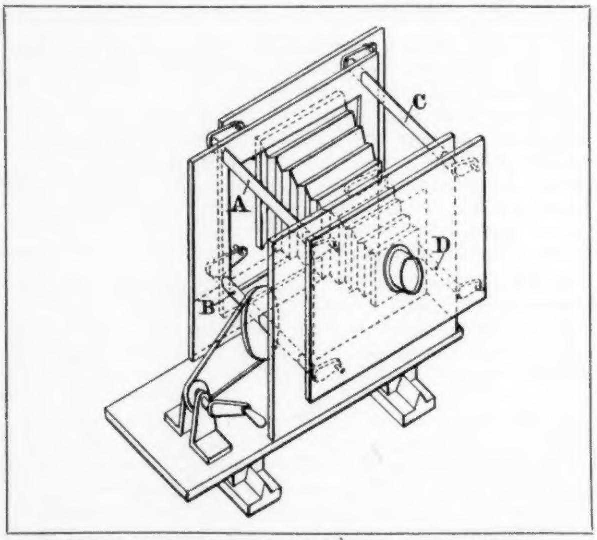


FIG. 3. DETAILS OF LUMIÈRE'S NEW CAMERA

of the object plane will be clearly defined. The angular orifices of the lenses at our disposal will suffice to enable us, provided a high value be given to h, to localize the extent of the clearness of definition in depth to a very reduced volume, but experiment demonstrates that in practice it is difficult, if not impossible to exceed, for the circumference described by the lens, a diameter of more than 80 millimeters. Under these conditions the apparatus will enable us to obtain, if a lens of comparatively large aperture be employed, highly interesting results, as was demonstrated by the examples exhibited to the Academy by M. Lumière.

PHOTOGRAPHIC RESEARCHES

THE researches made by the French scientist, H. Buisson and others concerning photographic plates as employed during the war have recently been made public. We refer especially to the data which have a general scientific character.

The first series of researches was made as follows: A continuous spectrum is projected upon the plate, with a constant exposure for each case, this being produced by a prism spectroscope with dark chamber or camera portion whose plate holder can be displaced so as to obtain several exposures on the same plate. The slit has a constant width and receives light from a 100-candlepower ½ watt incandescent lamp. After developing the plate during a standard length of time in a constant bath and at uniform temperature, the plate is washed and fixed. The amount of blackening of the various parts of the spectrum is then measured by the microphotometer devised by C. Fabry and H. Buisson, and the value is then plotted so as to form a curve whose ordinates represent the density and the abscissæ the wave-lengths. It should be mentioned that in order to effect the evaluation of the blackening of the plate, this latter is traversed by a beam of light, and the ratio between the intensity of the beam before it passes through the plate and after traversing the same (it being of course more or less diminished thereby), is termed the opacity or the blackening effect. The logarithm of the opacity is termed the density, and this latter is proportional to the amount of reduced silver per square centimeter of the plate. It is to be noted that the present curves for the blackening effect have only a relative value and hold good only for comparisons made with a given apparatus, since the spectrum is obtained by a prism which has the effect of condensing it toward the red, thus increasing the intensity in this region.

According to the results of these tests, the plates are classified in several groups, according to their sensitiveness to the spectrum. Setting aside the ordinary plates, whose sensitiveness is limited to the violet and blue, the first group will contain the plates showing their maximum effect in the yellow-green, comprising certain commercial German plates as well as some English plates. In this group some of the emulsions have only a slight sensitiveness for blue and violet, and can thus be employed without a yellow screen. The second group comprises plates of a maximum sensitiveness in the red, some of these being almost unaffected by the red-yellow, such as the English plates termed "red sensitive." A third group contains plates which have two or three very pronounced sensitive regions; blue, green and red, as well as plates having a practically uniform sensitiveness, or the panchromatic plates.

The second series of researches related to the general sensitiveness of the emulsions. In fact, it is not sufficient that a plate shall be acted upon by a given wave-length, but this action should represent the greatest possible amount for a given amount of light. For use in aerial photography especially, the best plate will be the one that gives an image with the shortest exposure. On the other hand, a plate should be chosen which has the best gradation according to the effect to be obtained, for instance in observation work it is of value to exaggerate the contrasts, since the purpose is not to obtain a harmonious image but to distinguish the smallest details and the least differences in intensity which will reveal the points which the enemy are trying to conceal. Researches upon sensitiveness and gradations are carried out by exposing the plates to lighting which has the same value but is applied in a series of varying exposures. The Scheiner sensitometer is found the most suitable for this work, its essential feature being a rotating disk having cut-out sectors whose width increases in geometrical proportion. M. Buisson used one of these instruments which had 9 sectors, each having double the angular length of the preceding, thus giving a series of exposures in the maximum ratio of 1 to 512. It is to be noted that these sectors are situated upon concentric circles, each sector or arc-shaped hole having a different length from the preceding, as stated, and the openings are not in the form of segments bounded by radii of the circle. The disk is rotated by an electric motor, and is located in a chamber placed back of the camera chamber. The light coming from a rather distant source will thus traverse the rotating disk and fall upon the plate. Color sireens can be interposed.

The plates are developed in an identical manner, then the densities are measured for all the regions acted upon by the light. The results are represented graphically by using as abscissæ the logarithms of the times of exposure given by the length of the sector openings, the ordinates being the densities of the corresponding regions. This gives a curve having a rather long straight part, representing what is sometimes called the region of normal exposure. The angular coefficient of this straight portion, termed "development factor," characterizes the degree of contrast which a given plate will afford. Where this factor is small the plate has but little contrast, and, if large, the plate has exaggerated contrast.

The X-Ray Detective

Some Curious Uses of the All-Seeing Roentgen-Ray

By Gordon Vanderveer

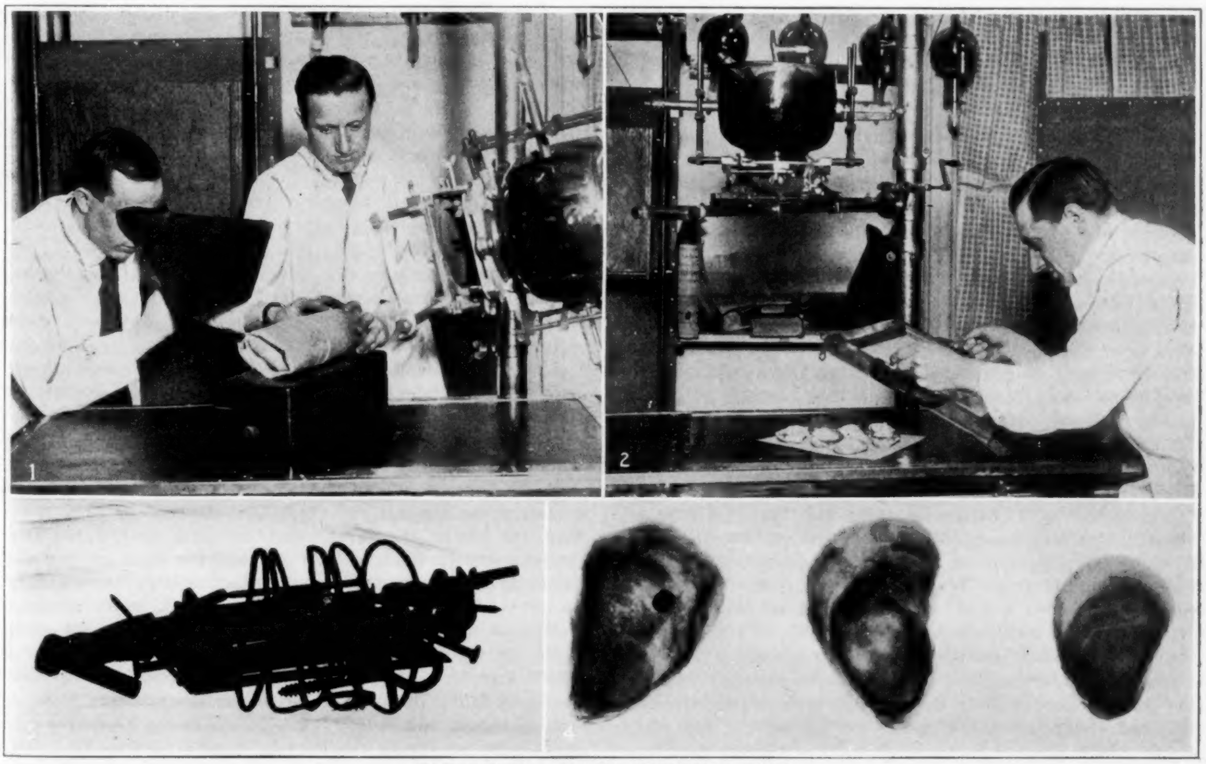
WE are all familiar with the use of the Roentgen rays in surgery to reveal the internal structure of a patient and locate the position of foreign bodies, or disclose the nature of a bone fracture so that the surgeon, before he undertakes an operation, is fully acquainted with the character of the trouble that he has to deal with. It is also generally known that the extent of certain diseases and their nature may be determined by means of these penetrating rays, and we have heard much of the use of X-rays in the treatment of various skin diseases. In fact, Roentgen rays have played so prominent a part in surgery and medical work that we are apt to lose sight of their employment in other fields of useful service.

Just now popular interest in these rays has been attracted by their recent employment in testing the genuineness of old paintings. As explained in the February issue of the SCIENTIFIC AMERICAN MONTHLY, the paints of old masters, having a metallic base, are more opaque to X-rays than modern paints, which are largely made up of vegetable and aniline dyes, so that when a modern painting is subjected to X-ray examination it is practically transparent and throws no shadows on the photographic plate. Paintings, which have long been considered the works of old masters and which have been subjected to minute scrutiny by experts without betraying any evidences of fraud, have been shown under X-ray examination to have been of modern origin.

There are other recent uses of Roentgen rays which are of considerable importance in research work. For example, there is a method of chemical analysis by which it is possible to distinguish the constituent compounds in an unknown powder, by comparing a photograph of this powder with one containing known elements and compounds. X-rays have also been used recently in determining the nature of precious stones and in distinguishing between stones, by noting their phosphorescent luminescence under the Roentgen rays. (See article on page 227 entitled "Is Heliodor a New Gem?")

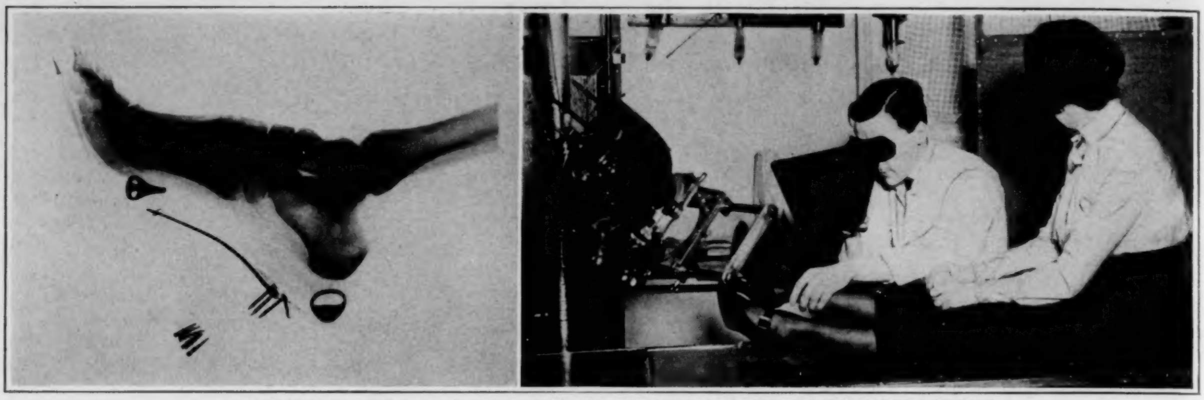
X-rays have been extensively employed for many years in detecting frauds, but as detective work must necessarily be veiled in secrecy, not much publicity has been given to this use of Roentgen rays.

During the war every effort was made to introduce contraband materials into Germany and if it had not been for the all-seeing eye of the Roentgen ray, it would have been impossible to prevent materials of the utmost importance to the enemy from reaching him by way of neutral countries. Efforts were repeatedly made to smuggle rubber and copper by burying them in bales or bundles of other materials. It would have been impossible to have made a minute investigation of every bale that was shipped, but by means of X-rays it was possible to see right through these bundles and packages and locate any substances that were more or less opaque to X-rays. Smuggling is extensively practiced in time of peace to avoid customs duties and for this reason wherever there is an occasion of suspecting a package, or even the wearing apparel of an individual, the X-ray machine is brought into service to search for hidden goods. One of our photographs shows a lady's shoe provided with a false sole in which two rings are embedded. X-rays have also proved useful in determining the nature of certain suspicious mail and express parcels. As shown in one of the illustrations, a harmless



TWO NOVEL USES OF ROENTGEN RAYS

In Fig. 1 a harmless looking parcel is being examined; Fig. 3 shows that it is really an infernal machine. In Fig. 2 oysters are being searched for pearls; the dark spot in one of the shells shown in Fig. 4 indicates a pearl



A SMUGGLER'S SHOE IN WHICH THE X-RAYS DISCLOSED TWO VALUABLE RINGS

looking package, on being subjected to the X-rays, proved to be an infernal machine of very ugly description.

A very novel use of Roentgen ray has recently been employed in Ceylon in order to search for pearls in oysters. Thousands of potentially valuable pearls have been lost to the world by the untimely opening of the oysters. Heretofore the pearl fisherman has had no way of telling whether an oyster contained a pearl of valuable size, or any pearl at all without opening the shell. In doing this, the oyster is liable to be killed and whether it contains a pearl of small size or no pearl at all, the fisherman must be content with what he finds. Were he able to see into the oyster without injuring it, he could pick out the bivalves containing large pearls and return the rest to the oyster beds. If they contained small pearls he could wait for them to grow to a goodly size. It is a simple matter to investigate a large number of oysters by means of X-rays and select only those which show large pearls, for pearls are opaque to the rays, and hence show as darks spots in the shell. By this means, much useless labor of opening shells is avoided and many pearl oysters are saved from untimely destruction and preserved for the growing of valuable pearls.

THE MECHANISM OF CHEMICAL ACTIONS CAUSED BY X-RAYS

THE experiments of C. T. R. Wilson proved definitely that the effects exerted upon matter through the absorption of X-rays are due solely to the corpuscular radiation which results therefrom. Fresh researches along this line made by the French physical chemist, M. A. Dauvillier, have recently been made and some of his conclusions were presented to the French Academy last fall, and are reported in the *Comptes Rendus* of that body for October 4, 1920. It occurred to M. Dauvillier that it might be possible to reduce the chemical phenomena which constitutes one of these effects, to a single type of reaction. He describes his researches as follows:

To begin with it is quite remarkable that the only mineral bodies which are sensitive to the action of these rays are those crystals concerning which it has been conceived and demonstrated by I. Langmuir, Born and Landé, Debye and Sherrer, that *they possess an ionic structure*. All other sensitive substances, including colloids, electrolytes, glasses, etc., likewise contain ions. It would appear from this that the cause of chemical action is to be found in the destruction of the negative ions, which are alone able to lose electrons, through the impact of the rapid electrons which constitute corpuscular radiation. The slow corpuscles expelled neutralize the positive ions in their vicinity and thus both electro-negative and electro-positive elements are set free in the atomic state. These produce coloration in solid or viscous substances, such as crystals and glasses, and actual chemical modifications in milieus within which they are mobile, such as electrolytes.

Let us consider from this point of view some of the more familiar reactions discovered by T. Villard: the violet coloration taken by alkaline glasses is due, according to this theory, not to an oxidation of the manganese but to a neutralization of positive ions with a liberation of the alkaline element in the atomic state, exactly in the same manner that a large number of crystals (sylvine fluorine, etc.) have a violet color imparted by the cathodic rays.

By means of this theory it is easy to explain the photo-electric properties of crystals and of colored glasses, and we can even understand their thermo-luminescence if we assume that there is produced (when they are heated to a certain critical temperature) a sudden thermo-electronic emission, beginning with the electro-positive atoms, with a consecutive ionization of the two types of free elements, and in consequence thereof an emission of light and a return to the initial state. We know, as a matter of fact, that under these conditions these substances lose their color and recover their power of becoming fluorescent. These phenomena cease to take place when the liberated element does not possess a sufficiently strong electro-positive character (chromium and the corundums transformed into rubies by X-rays or γ rays).

The brown color acquired under this influence by glasses containing lead is due in an analogous manner to the neutralization of Pb^{++} ions; the reduction of cupric silicate into cuprous silicate to the passage Cu^{++} ions into the C^{+} state; the Schwartz reaction to the transformation of mercurous ions, etc.

Levy has demonstrated (*Journal of Roentgen Society*, Vol. XII, 1916, p. 13) that the Villard effect is due to a destruction of a crystalline structure (without dehydration) of the stero-isomeric forms $Pt\ (CN)_4Ba4H_2O$. This question can be definitely answered only by a study of these crystals by the method of Debye and Sherrer. But we may assume that the ion Pt^{++} which is the most absorbent element of the crystal, is reduced to the state of atomic platinum, which produces the colorization.

As we know, this phenomenon, like all the chemical actions occasioned in crystals and glasses by the cathode rays, the β-rays, the γ-rays, the X-rays, and the ultra-violet rays, is accompanied with fluorescence, and that the light emitted possesses inversely the property of effecting the recombination. In my opinion this radiation operates no longer by means of corpuscles but quite *directly* and upon free *atoms* which alone are absorbent, producing a selective photoelectric effect which transforms them anew into ions. The free corpuscles are immediately fixed so as to reform the negative ions.

For example, when one exposes to light the platino-cyanide of barium colored by the X-rays, there is produced, starting with the atoms of platinum, a photo-electric effect which transforms them into positive ions, while the slow corpuscles expelled become fixed upon *the CN complexes which, in order*

to assume a stable electronic configuration in the crystalline space-lattice must exist there in the form of ions (CN^-).

The light will exhibit antagonistic properties only when the electro-positive element set free is photo-electrically sensitive in the spectrum of fluorescence of the solid or viscous medium.

According to this all the chemical properties of the radiations enumerated above must be considered as being due to the destructive action exerted upon the *negative ions* by corpuscles of a greater or less velocity (relation of the quantum), while the antagonistic properties of fluorescence (ultra-violet, visible, or infra-red) would be due to a photo-electric effect produced starting with normal *atoms*.

These reactions may be expressed by Perrin's equation:

$$\vec{Q} + P \rightarrow P' + \vec{Q'}$$

generalized by considering P and P′ to be the negative ion and the atom of the same electo-negative element; Q as the quantum given up to the ion through the reduction of velocity undergone by the rapid corpuscle; Q′ as that of the radiation of fluorescence equal to the work of ionization done by the atom P′.

Leonardo Da Vinci as an Inventor

Remarkable Achievements in Science and Invention of the Great Italian Artist

By A. A. Hopkins

AMONG the marking characteristics of the Renaissance—aside from a love of the antique world and an equally great devotion to the fine arts—were an unbounded curiosity, a thirst for fame, and a desire to develop and perfect the individual. This desire often resulted in men's engaging in many serious pursuits and studies which passed beyond the limits of dilettanteism. Leonardo da Vinci was a true son of the Renaissance in partaking of all these tendencies, and he was one of the few in all the race to whom it has been given to stand at one and the same time as the promoter and as the representative of a new civilization.

The materials for a definitive life of Leonardo are lacking; but from his manuscripts and sketches, and from the customary sources of information—documents both plastic and written—modern criticism with tireless patience has been enabled by synthesis to construct a tolerably accurate portrait of Leonardo the man, the artist, and the discoverer.

What astounds us most in reviewing the life work of this remarkable man is his versatility. Many of his predecessors had been so gifted that they could execute masterpieces in several of the arts, any one of which would have sufficed to make their author famous; many of his successors are so great that their achievements divide the suffrages of the world; but when universality of talents and effort are considered, all must stand aside in Leonardo's favor. He is not many-sided, he is all-sided—truly "*l'uomo universale.*" During his lifetime (1452-1519) every human attainment was his, and nearly every honorable pursuit, barring the commercial, was followed by him with more or less success. He had a rare combination of gifts for an artist, uniting the artistic or creative, the mechanical or inventive, and the speculative. These first two phases of his personality are usually considered incompatible; but in Leonardo these prodigious faculties were nearly always maintained in perfect equilibrium; the artist and the savant did not displace each other. He was painter, sculptor, architect, poet, musician, philosopher, psychologist, author, critic, traveler, aeronaut, mathematician, physicist, chemist, geologist, mineralogist, zoölogist, botanist, geographer, meteorologist, astronomer, anatomist, physiologist, surveyor, topographer, engineer (civil, mechanical, mining, naval, and military), and inventor!

It must not be supposed that success always attended the results of this curious intellect's delving in the great storehouse of nature; on the contrary, he was often foiled, and many of his undertakings ended in failure. He was dreamy, procrastinating, a lover of courts, the lute, and improvisation; so that his temperament was largely responsible for his failure to execute or formulate works and theories which the brain had conceived. With fewer gifts, the harvest would perhaps have been greater. The real and apparent disorder in which he left the product of his meditations resulted in an ignoring of his real claim to be heard until the modern scholar cleared away the mists which surrounded his memory.

Though probably only a fraction of his writings and sketches have come down to us still they show that science had its renaissance in Italy one hundred years before Galileo. Leonardo was the connecting link between Archimedes and the modern world, and many of the discoveries which he made remained embalmed in masses of old papers, thus giving an opportunity for men of lesser caliber to rediscover these facts and give them to the world.

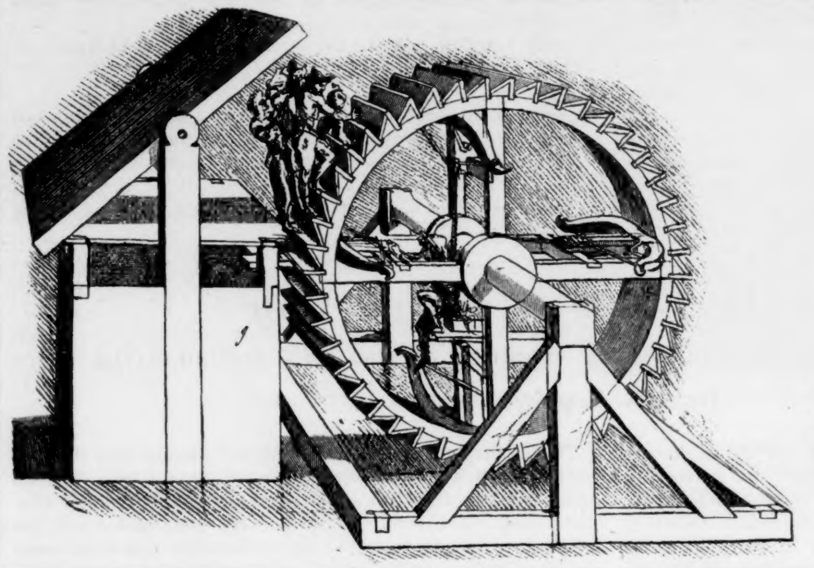
No other old master has left so many manuscripts; they consist of written memoranda with or without drawings, the latter often having no relation to the text. It is not strange when the encyclopædic nature of these writings is considered, that these manuscripts have been studied by specialists and societies of savants. The deciphering of these documents is rendered doubly difficult by Leonardo's extraordinary system of reversed writing; this matter has never been explained satisfactorily, as he wrote in the ordinary way when he chose. Still, from these bundles of old papers, the scholars who have studied them have found inedited chapter after chapter in the history of science.

Leonardo the artist—the painter, sculptor, and architect—does not come within the scope of the present article, which concerns only his scientific and mechanical achievements. It is but natural that a great thinker like him should have been fascinated and awed by the celestial world. He investigated the phenomena of the fixed stars and their luminosity. His pages concerning the moon bristle with original observations and ingenious theories. He accepted the spherical shape of the earth as an axiom; he believed also in the earth's rotation; and in a remarkable passage he says: "The sun does not move." He really forestalls Newton by indicating the universality of gravitation. He also knew of magnetic attraction, and the effect of the moon upon the tides.

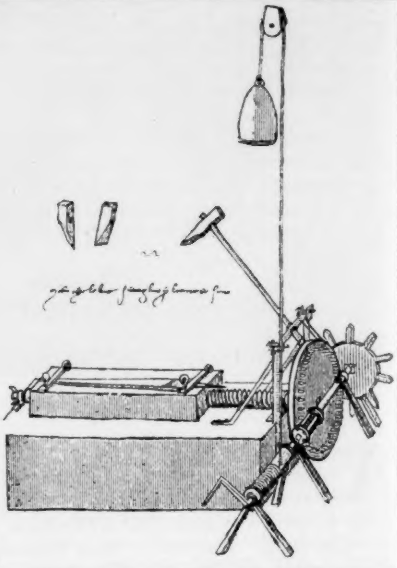
Leonardo was never tired of watching the clouds, and evidently meteorological phenomena had a fascination for him. He investigated the structure of hail, and invented the hygrometer. He also constructed instruments for measuring the flow of water and the speed of vessels.

The geological and physiographic problems of the history of our globe interested him. He seems to have had the correct theory of the elevation of continents and the true nature of fossil shells. The bulk of his writings on geography are devoted to water. He shows the true scientific spirit here, as elsewhere, in exhibiting patience and a reserve in dealing with facts which he has not himself observed.

Living as he did in the beautiful Val d' Arno with his myriads of wild flowers, it is little wonder that botanical questions should have attracted Leonardo. He collected plants, dried and pressed them; he established herbaria, and devised a method of obtaining leaf-prints which is in use today. His drawings of flowers and leaves are very numerous, and are of scientific accuracy. He studied vegetable physiology, the laws which determine the existence and multiplication of



MILITARY ENGINE DESIGNED BY LEONARDO, FORERUNNER OF THE MITRAILLEUSE



LEONARDO'S INGENIOUS FILE CUTTING MACHINE

plants. Long before the time of Grew and Malpighi he had discovered that it is possible to determine the age of a tree by means of its rings.

Vasari states that Leonardo studied anatomy under Marco Antonio delia Torre; and Leonardo's writings and drawings show that in the history of medicine he deserves a high place, his work bearing the stamp of much originality, as his drawings of anatomical subjects are ages removed from those in the medical works of his time. We have even reason to believe that he was acquainted with the circulation of the blood. He was the founder of the science of comparative anatomy; for, being struck with the analogies of the same organs in various animals, he proposed to make a systematic study of them, beginning with man, then the ape, etc. His studies led him to the unique conclusion that man is a quadruped, as the child walks on hands and feet!

He made great progress in mathematics and natural philosophy; we know that he was proficient enough in the former to assist the eminent mathematician, Paccioli. He is rather doubtfully accredited with the invention of the algebraical signs + and —. He calculated the method of finding the center of gravity of pyramids. He restored the laws of the lever; he knew the laws of impact and of friction, and the principle of virtual velocities; and he studied the time of the descent of bodies down inclined planes and circular arcs. He foreshadowed the undulatory theory of light and heat, applying the laws which govern the motion of waves to the theory of optics and acoustics.

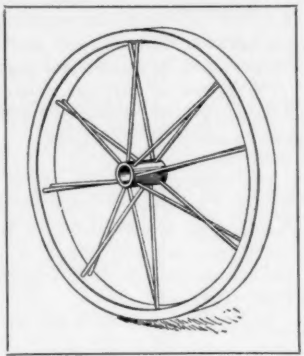
His famous "Treatise on Painting" is filled with remarkable sketches showing that he was familiar with the laws of light. It is believed by some critics that he invented the "camera obscura." It is thought that he divined the true action of the eye, the movement of the iris, and the duration of the image on the retina. He was acquainted with the facts of combustion and respiration. We owe the modern lamp chimney to him, as well as the glass water globes which are used to encircle lamps. He made curious figures out of the intestines of animals and filled them with heated air, so that they rose quickly; here was the germ of the Montgolfier balloon. Leonardo is believed to have surmised the molecular composition of water. He also devised terrible Greek fires.

Leonardo the engineer and inventor will have have a special interest to those who live in this inventive age. The rude tools of the laborer which were used by the men that Leonardo employed in carrying out his undertakings, exasperated him; and he made every effort to devise labor-saving inventions. Unfortunately, we do not know to what extent these various inventions were adopted. The position of a machine in the time of Leonardo was curious. In the petty cities and republics, machinery was the property of the State; and to betray its construction was a crime of *lèse-cite*, punishable by death. Rulers even declared wars in order to obtain the secret of a new industry; so it is little wonder that a genius like Leonardo should have been coveted by sovereigns.

In civil engineering Leonardo was so proficient that he was employed by such rulers as Cæsar Borgia. He understood the boring of tunnels and the cutting of canals, devising ingenious excavators which embanked the earth taken from the cutting. His arrangements of derricks, pulleys, screwjacks, and rolling cranes were of great interest. The obelisks in London and New York were set upright by the same means which Leonardo employed to raise a column. We possess a project by him for lifting up the Baptistry of Florence en masse and setting it on a new foundation. Bronze-casting he was also acquainted with, including piece-molding, while he had a rare knowledge of the physical properties of both metals and alloys. The few fragments on the resistance of beams which remain to us show that he was deeply versed in what we fondly consider a new science—the "strength of materials."

All his life long Leonardo seemed to be interested in water, which he describes as the "great carrier of nature." The drainage of marshes by siphons, the irrigation of land, the dredging of rivers and harbors by a rotary bucket-dredge, were planned out with infinite care for details. He devised ways for making useful a stream not navigable either by reason of too slight a depth or from liability of failure in time of drought. He proposed a series of diagonal dams with locks at the angle. Similar methods are today used on the Marne, the Seine, and other rivers. His plan for rendering the Arno navigable was rejected with scorn, but was carried out two hundred years later. He invented all kinds of water wheels, undershot, overshot, and breast; some of his wheels were placed horizontally, and the idea of the Fourneyron turbine originated with him. His schemes for raising water from a lower to a higher level are numerous and interesting and some of them are in use today. He also made sketches of swimming-machines, and he devised the precursor of the modern pneumatic life-preserver.

The stone-saw invented by Leonardo rendered quarrymen independent of natural cleavage, and saved untold time in smoothing. A similar saw is now in use at Carrara. Of the stone-saw we have over thirty rough sketches before the perspective drawing of the machine, shown in our engraving, was made. He was the true engineer, dashing off his ideas roughly at first, and afterward elaborating the machine in all its details. The file cutting machine is one of the most remarkable of his inventions. It was entirely automatic, power being provided by the descent of a weight. The file was held in place by clamps on a movable bed which brought the blank under the hammer, which delivered its blows by a tripping mechanism. A very similar machine is at present employed for the same purpose. He also designed a machine for boring out wooden pipes, as well as a saw for wood. His metal-planer does not seem to have been successful, though he had the correct idea. His rope-making machine possesses positive merit, while his drop forge press, door-spring, color-grinder, chimney-hood, odometer, nap-shearing machine, loom-calculations for textiles, and spinning machinery, are all remarkable. The suspension wheel invented by Leonardo is used today in the bicycle and automobile. It was a great improvement over the old "compression" wheel, the load carried upon the axle being suspended from the rim instead of being supported on the spokes which fall beneath the axle. The roasting jack which turns automatically by means of heated air is also due to him. His studies on windmills are very interesting.



LEONARDO'S SUSPENSION WHEEL

Leonardo was undoubtedly the first aeronautical engineer and he may be regarded as an inventor of the helicopter and also of the basic flying machine, particularly of the one by which Lilienthal met his death. The treatment of this subject will be deferred to a later issue of the Scientific American Monthly, when it will be adequately treated with a number of highly interesting illustrations.

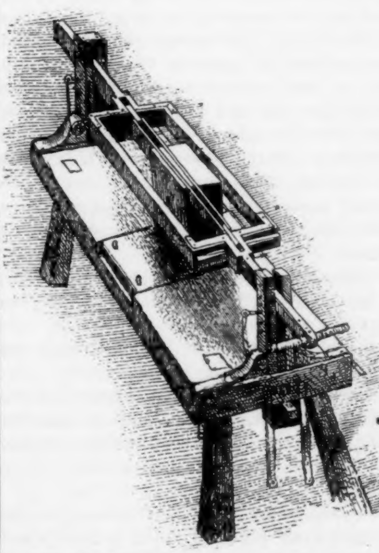
As a naval and military engineer Leonardo was truly terrible. In the memorable letter intended for the Duke of Milan, which is one of the curiosities of the Renaissance, he describes the various engines of war which he could fabricate, and the means by which he could overcome the enemy. Leonardo has left hundreds of sketches of catapults, ballista, gigantic cross-bows, breech-loading cannon, mitrailleuses, serpentine organs, and steam cannon. The breech-loading cannon antedated Leonardo, though he made substantial improvements in it. He devised breech-loading mitrailleuses for giving both a parallel and a fan-shaped fire. He it was who discovered the secret of the conical rifle-ball. The steam cannon invented by him consisted of a copper tube one-third of which was subjected to fire contained in an open basket. When the breech was very hot, water was introduced into the barrel; it was instantly vaporized, discharging the projectile with great force. The Serpollet boiler of today is built on the same plan. When it is said that Leonardo understood the principles of the very modern "built-up" gun, it may well be said that this might be called his greatest title to fame as an inventor. He has left minute sketches of guns reinforced by hoops shrunk on, of guns composed of sections welded on, and of wire guns. The latter are the most interesting. In Leonardo's designs the reel is shown around which the wire is wound. He also devised special machinery for drawing the metallic tape for use on the gun exactly to gage.

The brain whirls when the achievements of this remarkable man are reviewed. It is little wonder that the men of his time considered that there was something uncanny about him. It is not strange that Vasari should have used the word "divine" in speaking of him. Notwithstanding his performances in all the arts and sciences, he seems to have considered painting as his chief occupation in life. The artist-critic, Mr. Edwin H. Blashfield, expressed the thought with rare felicity when he wrote: "A man who had the whole book of nature open before him as the subject of his commentary, could leave a miniature here and there at most. His art was only the rubrication which made the text fairer to look at." It is perhaps fortunate that we, with our twentieth-century pride in recent victories of science, art, and invention, can look back four hundred years to the century of the "discovery of man," and see in the colossal form of Leonardo da Vinci the very incarnation of the aims and ends of the Renaissance, the springtime of the modern world.

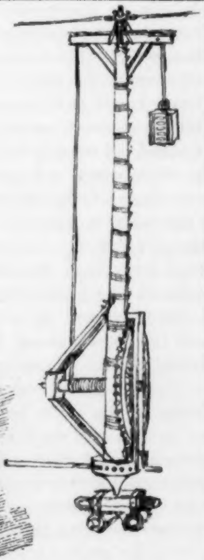
TURNING LOSSES TO PROFITS

Forrest Crissey is the author of a little book entitled, "Laboratories That Turn Losses to Profits," and in it we find numerous examples of how laboratories have been able to accomplish this desirable purpose. Having often heard sarcastic comment on the small percentages of substances sometimes reported by a careful analyst, these being frequently regarded by the layman as unimportant, we cite two examples given by Mr. Crissey to emphasize again the real importance of traces.

On one occasion a dealer in molasses desired to please a distributing house and so substituted a better and more expensive grade of molasses for one specified in a shipment which was to go to Newfoundland. Much to his surprise there was a great complaint from the consumers and an investigation was started. It seems that in Newfoundland molasses at that time was largely used for sweetening tea and they had been in the habit of buying molasses from Barbadoes where it is customary to employ only copper kettles in its manufacture. The dealer had substituted a finer quality of molasses from New Orleans and in Louisiana it is customary to boil molasses in iron kettles. Now when the merest trace of iron comes in contact with tannin a black precipitate forms, so when the users of the New Orleans molasses in Newfoundland sweetened their tea it turned black. There



MARBLE SAWING MACHINE



TRAVELING CRANE

was no more than a trace of iron, but it was sufficient to do the damage.

Again an American manufacturer found it necessary to obtain manganese dioxime from a new source in order to fill a European order for dry batteries. Ordinarily the ore used comes from Russia and contains 80 or more per cent of manganese and one per cent or less of iron. An ore in South America was found which met this specification and was used in one million dry batteries which tested satisfactorily before shipment. Before long, however, the manufacturer received complaints and the European customer returned the shipment. Meanwhile the ore was subjected to a very careful analysis and found to contain from ten to fifteen one-hundredths of one per cent of copper. This copper was enough to do the damage for it had formed a delicate film over the zinc causing resistance to be increased to the point where the full electromotive force expected could not be delivered.

The little book is interestingly written and affords good reading to him who may still doubt the practicability of putting science on his payroll.

THE OIL SHALE INDUSTRY

THOSE who have been interested in the development of the oil shale industry would do well to read the article, "Problems of the Oil Shale Industry" by the state geologist of Colorado, R. D. George, in the December issue of *Chemical Age* (New York). In the January issue of the same publication there is a summary of the commercial development of chemical engineering in shale oil recovery which should be reviewed at the same time. This summary gives the names of the processes of which there are seventeen, and then continues with such details as the name of the owner with address, the type of material of construction, method of advancing shale through the retort, the through-put in twenty-four hours, dimensions of retorts, the type of feed, and of discharge, the size of shale treated, the nature and method of applying the fuel used, the temperature required in the various zones of the retort, method of withdrawing the gas and oil vapors during the process, when and how steam is used in the process, the present stage of the development of the process in each instance, and notes on special features. This summary affords a good opportunity for carefully comparing the different processes that have been brought out and for which in some instances support has been sought.

In discussing the problems of the oil shale industry, Professor George takes up the problem of retorting under five principal heads. These are:

"1. To convert as much as possible of the oil-making material of the shale into oil or other useful products.

"2. To secure a crude oil containing the largest possible percentage of the most valuable constituents, such as gasoline, keresene and lubricating oils, and the smallest possible percentage of worthless and harmful materials which must be removed as waste in refining.

"3. To secure a crude oil which is easily fractionated into gasoline, kerosene, lubricating oils and others, and which yields fractions of cuts which are easily refined.

"4. To secure as large a yield of ammonia and other valuable by-products as possible without sacrificing more desirable results.

"5. To reach the highest commercial efficiency without sacrificing the raw materials of the company or of the country."

After discussing these problems at some length he takes up those of refining and of by-products. Since a strong point is always made with reference to the by-products of the industry, the following is quoted from the article under discussion:

"Other By products.

"Much nonsense has been written about the many valuable by-products of oil shales. It is true that many commercial products can be made from the shales, but most of those commonly listed can be made more cheaply from other forms of raw materials. This is true of dyestuffs, medicinal salts and many other chemical substances.

"A substance resembling ichthyol has been made, but it is very doubtful that true ichthyol has been produced.

"Synthetic rubber has been much talked of but it is safe to say that nothing approaching a commercial process or a commercial quantity has been discovered.

"A substance resembling gilsonite and possibly suitable for a rubber filler may be separated from the tarry residues.

"Paraffin wax of high grade and readily marketable may be produced in commercial amount and profitably.

"Analyses of several samples of spent shale showed an average potash content of eighteen pounds per ton of spent shale. This is water-soluble, and could be leached out at little cost.

"The spent shale has been proclaimed a fertilizer, but it contains nothing of value in this way except the potash and it would be absurd to list it with fertilizers.

"It has also been talked of as raw cement material, and as brick material. It is of less than average value for either of these purposes.

"One advertiser of shale oil stock has found that it is the best of material for glass and porcelain making. This is nonsense.

"It is not even good road material and its disposition will present a problem.

"The tars, still carbons, or coke and the heavy residual oils will be utilized about the plants or converted into marketable products.

"Lubricating oils of the highest grade are made from the Scottish shale oils, and laboratory quantities of lubricating oils made from Colorado shale oils have been given extraordinary results when tested in actual use. They retain their viscosity or body at much higher temperatures than do oils of similar density and flash point made from well petroleum.

"Much information is being given out regarding the precious metal content of the spent shales. A large number of assays by thoroughly reliable and competent chemists and assayers, have failed to give a single return which could by any reasonable means be called commercial. Traces of gold were found in possibly one-half of the twenty-two tests made by the Colorado Geological Survey."

THE CRYSTAL STRUCTURE OF ICE

IN *Science* for September 24th 1920, Mr. D. M. Dennison of the Research Laboratory of the General Electric Company at Schenectady, makes a brief statement of the results of investigations on the crystal structure of ice.

X-ray photographs of ice were taken to determine its crystal structure following the method used by A. W. Hull. The lines on the film correspond to those of the hexagonal system. They show that ice has a lattice which is built up of two sets of right, triangular prisms interpenetrating one another in the following way. Consider the plane containing the bases of one of the sets of prisms. The molecules lie at the vertices of equilateral triangles of side 4.52 Ångströms. At a distance of 3.66 Ångströms above this plane lies the plane containing the bases of the second set of prisms. Here the molecules also lie at the vertices of equilateral triangles equal to those of the first set, but each molecule is situated directly above the center of one of the lower triangles. The other molecules of the crystal will lie directly above the molecules of the two planes just described at intervals of 7.32 Ångströms. The above values give an axial ratio of 1.62 in good agreement with the crystallographer's value of 1.617. From these data the number of molecules at each point has been calculated to be two.

This means that the molecule of ice must be of the form $(H_2O)_2$ or H_4O_2. The full data and calculations will be published in the *Physical Review*.

Science and National Progress

Edited by a Committee of the National Research Council

Dr. Vernon Kellogg, Chairman, Dr. R. M. Yerkes, H. E. Howe

The National Research Council is a cooperative organization of the scientific men of America. It is established under the auspices of the National Academy of Sciences and its membership is largely composed of appointed representatives of the major scientific and technical societies of the country. Its purposes are the promotion of scientific research and of the application and dissemination of scientific knowledge for the benefit of the national strength and well-being.

TROPICAL FORESTS

By H. N. Whitford

Yale School of Forestry

The world contains two great forest belts, the one in the north temperate zone and the other in the tropics. Both are interrupted in their continuity by grasslands, deserts and oceans. The one to the north, because of its great change of seasons, has but a part time capacity for productivity. It means that Nature's great wood manufacturing laboratory is running only half time. In the tropical belt, midway between the poles, where the wood manufacturing plant runs the year round, the capacity to grow timber per unit of area is theoretically twice that of the northern belt.

In past geological ages, due to changes in climate, the torrid zone with its existing forest vegetation has spread toward the poles; at other times the north temperate forests have been pushed toward the equator at the expense of tropical vegetation. It was at the beginning of the glacial epoch that the progenitor of man was supposed to have found himself in a different environment from that of his native tropical forest. He must change his habits or perish. Primitive man was the result. During the whole Pleistocene epoch, with its four distinct glacial and interglacial periods, mankind spread to the four corners of the globe. It is only since the last ice sheet that primitive civilization arose in central Asia. It spread to many parts of the globe. In its westward movements it found an environment favorable to its rapid development in western Europe and later, North America, and what we call modern civilization came into being.

In the spread of primitive civilization it has encountered certain natural obstacles in its way. These are the desert, the mountains, the forest, the sea, and the rigors of winter. It was the overcoming of these obstacles that increased man's brain power and has resulted in our modern civilization.

In this struggle the forests, at first an obstacle, have played no small part. Their products furnished fire wood for cooking purposes and timber to build houses and minimized the rigors of winter. They supplied the materials that built the ships that conquered the seas, the highways of the world. One need not enumerate the thousands of uses to which forest products today are put. In spite of the many substitutes for wood the per capita consumption is increasing. Naturally the forests nearest at hand, or those of the north temperate zone are the ones that have been most drawn on. Each successive virgin forest has been attacked, destroyed, or badly damaged and the operations transferred to another place. In western Europe the virgin forest has disappeared. Planted or well managed second growth forests have taken their place. In the United States of the original 820 millions of acres on which nature's chemical wood factory had produced stocks of timber ready for the axe, but 463 million acres are left. Of this amount 137 million acres or 1/6 of the original area is virgin forest, 80 million acres is unproductive waste. More than half of the remainder is small timber of inferior quality.

Nature's wood chemical laboratory needs to be protected against the further ravages of man. It has been so badly damaged that it will take many years for its recovery. Especially is this true in the eastern part of the United States where there is a shortage of wood already. Even if the severe measures advocated by the most radical forest economists were put in effect tomorrow, it would be many years before timber could be utilized. Certain of our industries, some of them basic, that depend in part or wholly upon forest products, are feeling the shortage of raw materials. The average citizen feels it in the much higher prices he has to pay for everything made of wood.

It is known that the vast areas in the tropics are covered with forests. Do these forests contain wood products that will aid materially in the further development of our modern industrial civilization? This question has been answered pro and con. But the answer either way has not been satisfactory because much investigation is necessary before the truth can be known.

It is true that the wood products of the tropics have played only a very small part in our economic life of today. Statistics for 1913 show that not much more than 150 million board-feet reached the United States from tropical countries. More than half is classified as mahogany and Spanish cedar, and much of the remainder are cabinet woods of various kinds. On the other hand, until recently, the northern belt of forests ships annually more than ten times this amount or number, mostly construction timbers, to tropical countries. There is no tropical country that has an industrial development worthy of the name, but has been the recipient of the products of our forests. This has led some forest economists to the belief that tropical forests contain nothing but hard, heavy woods suitable only for cabinet work or furniture manufacture or for other special uses that do not need large quantities of timber. Where investigations have been made, as in the Philippines and British North Borneo, this has been proven not to be the case. On the other hand, these investigations show the forests are more abundantly supplied with soft hardwoods that can and are being substituted for the same uses to which the pines and oaks were formerly put. It has been estimated that in the Indo Malay region there are about 1,600 billion feet of standing timber ready for the axe, or about the estimated amount that is contained in our Pacific Northwest.

The area of standing timber in the Amazon Valley is estimated to be over one billion acres, or more than twice the forested area of the United States. Before the writer had seen the forests of the coastal region of Dutch Guiana and the coastal region of Brazil, he estimated the stand of timber in the Amazon Valley to be 3,400 billion feet or 600 billion feet more than is contained in the United States. He now believes that estimate is too low and that the figures given are ultra conservative. In tropical America besides the Amazon region, in Brazil, in the Guianas, Colombia, Venezuela, Central America, southern Mexico and in Paraguay and neighboring parts of northern Argentina there are large areas of forests. The Belgian Congo region alone is estimated to contain 448 million acres of forests of one kind or another. With the exception of a comparatively few woods that reach our markets and those of Europe, usually the gold nuggets of the forest, we know little about the capacity of these forests to produce timber for the more general use of industrial civilization.

One of the first steps to gain the required information is a

knowledge of the forest flora of these regions. Much progress has been made in the classification of the forest flora in the colonial possessions of the United States and European nations. Especially is this true of India and the Philippines, the Dutch East Indies, some colonial possessions of Africa and elsewhere. Some progress has been made in tropical America. The first fascicle of a publication entitled "The Trees and Shrubs of Mexico," has recently been published. The West Indies and parts of Central America have been fairly well combed in a general botanical way. Recently a combination of three of our largest herbaria has undertaken to direct its attention to northern South America. Our herbaria contain much material that needs to be worked up, but the corps of trained men is far from being adequate. The systematic botanists of our country should be encouraged in every way possible to continue the work already begun.

While systematic work is necessary for an understanding of the composition of the forest, yet this is only a classification of the forest composition from a qualitative standpoint. A quantitative as well as a qualitative analysis of the forest is necessary to know its economic value. Because we have depended on the former rather than the latter studies of tropical forests, a widespread misconception of their nature and economic importance is current. It is interesting to know that in the Philippines there have already been classified 2,600 tree species in an area of 120,000 square miles, or about three times as many as are found in the whole of the United States, distributed over an area of more than three million square miles. Yet from an economic standpoint it is much more important to know that more than one-half the standing timber of the Philippines is composed of less than 20 species and that when the lumber of these is put on the market for general use they fall into three groups, one a group of hard durable timbers for construction work in contact with the ground, another, moderately hard non-durable timbers for heavy construction work not in contact with the ground, and a third group, by far the most abundant, composed of comparatively soft non-durable timbers that are being used for light construction work. It is true that sometimes the wood of a particular species of any one of these groups is preferred for special uses. Before it can be stated that similar conditions exist in the virgin forests of the American and African tropics more extensive studies are necessary. Indications point to the fact that the composition of the upper story or two upper stories of the forest, and these are the stories that contain trees of merchantable size, are more complex than those of the Philippines, but much simpler than a census of the trees of all the stories of a given tract would show. Thus, published accounts of a census of forests made in British Guiana show that in one type of forests covering large areas three species formed 45.7 per cent of the trees; 7 species, 61 per cent. In another type one genus and two species formed 42.8 per cent of all the trees. Still other types showed similar conditions. These studies were based on counts by diameters and not by volumes. Had an estimate been made by volume it is believed that the percentage of the leading species would have been higher. The writer has had an opportunity to make detailed studies for limited areas in two places in the American tropics. In one case 90 per cent of the timber of merchantable size was of one species, a hard, heavy wood suitable for ties. This was in a dry region and the amount per acre was light. In another region in one type 100 per cent of the timber reaching merchantable size was of one species—a soft hardwood. On the property examined there were 8,000 acres in this type and the stand would average 25,000 board-feet to the acre, in some places 60,000 to 70,000. This is exceptional, however. In an adjoining type, which because of lack of time was not studied in detail, perhaps 8 or 10 species would yield 60 or 70 per cent of the cut with the stand per acre much lower. Cursory examinations in other parts of the American tropics show conditions similar to the last. These examinations are not extensive enough to make general conclusions.

The above is given to show the necessity of investigation. Expeditions to carry on the work could well be confined for the present to the more accessible areas. The personnel composing them should be equipped to collect botanical material including wood samples, to map the areas covered and roughly estimate the amount of timber by kinds. Especial attention should be paid to the woods known in the local markets and to those species that are most abundant whether or not they are known to be of use. All forest products other than woods should be studied and samples collected.

Another line of investigative work is the classification of the woods. Good work has been done on the woods of India, the Philippines, Java and other colonial possessions in the tropics. While some progress has been made in the American tropics, the field for study has hardly been touched. One institution in the United States has undertaken this work, but because of lack of financial support the progress is slow. The importance of this work will become apparent when it is stated that there are numerous requests for identification of tropical woods that have entered our markets. There are requests also for information concerning tropical substitutes for many of our own woods that certain industries depend upon. These requests are made because such industries are getting anxious about the future source of supplies.

While our modern industrial civilization has depended on the tropics for its woods de luxe only and has furnished their people with a considerable supply of their construction timbers, it has gone to tropical forests for other classes of products that have become indispensable to some of its basic industries. Aided by the increased energy of the tropical sun, nature's chemical laboratory is able to produce, besides wood, a greater abundance of certain by-products than is possible for its less energetic competitor in temperate climates to do.

Thus modern civilization today is depending on the tropics for rubber and its allies gutta percha, balata and chicle. Resin-like substances, oils dye woods and tannin products play an important part in our arts and sciences.

The products of tropical palms play an important part in our everyday life. The soap with which we take our bath may contain palm oil. We may put on a coat that has buttons made of the nuts of the ivory palm. The hat we wear may be made of the fibers of the Panama palm. Some ingredients of the explosives we used to help win the war may have come from a palm, and the best charcoal used in the gas masks that protected our men on the battlefield may have been obtained from the shells of several species of palm nuts. The candles we burn may be made of the wax taken from the leaf of a palm. The rattan chairs we sit on and the canes we carry may have come from climbing palms that grow in a tropical forest. The mattress we sleep on may be made of kapoc, the product of the fruit of the silk cotton tree. We are dependent on the tropics for such important medicines as quinine, ipecac, and a host of others used in pharmaceutical science.

Only a few of the hundreds of different kinds of products which the people that live in or near tropical forests make use of in their daily lives, reach our markets. Many do not reach the local markets. As they are better known they may become an article of local trade and then ultimately reach the world's markets. The history of the discovery of many of the products and their introduction into our markets reads like a romance.

Most of the raw materials from which the articles cited above are made are still gathered in virgin forests. One by one as the articles become more essential to our modern civilization, experiments are made to test the possibilities of their being raised profitably as cultivated crops. Take the case of Para rubber for instance. In its native home, the Amazon River, the trees grow far apart and the cost of collecting is great. Our knowledge of the existence of rubber dates back to the discovery of America by Columbus who is said to have seen natives playing with rubber balls in the island of

Haiti. It was first used, long after, to remove pencil marks. Later the Mackintosh firm began to manufacture waterproof coats, but it was not until after 1839, when Goodyear discovered the process of vulcanizing it, that the Mackintosh waterproof coats came into more general use. The British Government, ever keen to get valuable products growing under its own flag, encouraged its introduction into the Ceylon in 1876 and cuttings from these plants were distributed to other parts of the British empire throughout the tropics. It was not however until the first decade of this century when the automobile industry began to demand large quantities that commercial plantations were established. In 1910 the world's production of rubber was 68,200 tons, 12 per cent from plantation rubber. In 1920 it is estimated to be over 300,000 tons, 90 per cent of which is from planted rubber and most of this from the Federated Malay States and neighboring regions, one of which is Sumatra. It is here that American capital has made its investments under Dutch control. While much investigation has been made in increasing the productivity of rubber trees in plantations, research problems in the management of the cultural forests to give maximum results are still in progress.

Of importance to us as a nation is the possibility of extending the growing of Para rubber nearer home. Plantations in various parts of the American tropics exist but so far generally have not been successful. Investigation work here is of prime necessity. It involves research work in the methods of protection against a disease that is present only in the American tropics.

Because of political control and economic conditions connected with supplies of labor, European nations have introduced other forest products whose native home is in the American tropics, into their eastern colonies. Among these are the cultivation of the Cinchona tree (quinine) and the silk cotton tree (kapoc). Thus today Java produces most of our quinine and nearly all the kapoc.

The writer cannot leave the subject of Tropical Forests without a word concerning the possibilities of the tropics for growing crops of trees for their timber and its by-products such as cellulose. In the production of wood supplies, the English in British India and to a less extent the Dutch in Java have made advances. The British, not content with managing their valuable natural forests which contain teak to yield continuous supplies of timber, have planted large areas which are yielding returns. The Dutch also have extensive forest areas planted in teak. Experiments in teak planting are under way in other British tropical colonies in Trinidad and West Africa especially. This includes experimental plantations of such valuable woods as mahogany and Spanish cedar and others.

While much research in rapidity of growth of planted tropical trees and other plants has been made, and indicate that crops of timber will reach maturity in a much shorter time than in our own climate, much investigation is necessary before the exact time it will take to raise such crops on a commercial scale can be determined. That there is great variation in the rapidity of growth according to the species and to the nature of the habitat is true for the tropics as well as for temperate regions. Measurements made recently in virgin forests of the Philippines indicate that the annual increment per year is 1.91 per cent of the mature stand. It has been estimated that the annual growth in our southern pine forests is one per cent of the mature stock on hand. If these estimates are correct it means that the tropical sun has annually somewhere near twice the capacity to store up energy in the form of wood, than does the temperate sun. To put it in another way, one acre of ground can grow as much timber in a year in the tropics as two acres in the colder climate.

The above-mentioned estimates were made in the dense forest and show that the large trees have a much more retarded growth in their younger stages than do many of our own species in our climate. It is only when they reach the middle and upper layers of the forest that they overtake and pass in rapidity in growth many of our own species. Estimates in growth on the same species in the forest and in the open show that in the forest it takes about twice as long to reach a diameter of 12 inches as it does in the open.

The same investigator made measurements in the second growth forests and compared them with the average growth of a large number of species in the United States. This shows that it takes our species on an average of 68 years to reach a diameter of 14 inches, whereas the Philippine species measured reached the same diameter in 17 years. According to recent investigations made by Dr. Rowlee in the rich bottom fruit lands of Central America, crops of timber of balsa wood averaging 20,000 board-feet per acre can be raised in five years. In the Mississippi Valley, it takes cottonwood, our fastest growing hardwood, 30 years to yield the same amount of lumber. The above examples are given because the forest of the tropics contain many soft wood species whose specific gravity is about that of spruce and white pine. Some of these occur in pure or almost pure stands on cut-over lands and reach maturity in 15 to 20 years. Others occur in virgin forests, and in certain habitats constitute the bulk of the stands, in one case at least, all of the stand over limited areas. They reach huge dimensions, six feet and over in diameter, 150 to 200 feet in height. The indications are that they attain maturity in 75 to 100 years or less.

If investigation should show that one or more of the many kinds should prove suitable for paper pulp, crops of timber could be raised in one-fourth to one-third the time that it takes to produce a similar crop of spruce in our temperate regions.

In the above there has been an attempt to bring together a few of the facts concerning tropical forests, the extent to which they are used, and their rate of growth. Our knowledge concerning the possible uses to which many of their products could be put is limited. Much pioneer investigation along the lines suggested above is needed before we can answer many questions. The tropical sun has stored up energy in the form of wood and other products that are today little used. It is shown that it has the power per unit of area to produce annually two or more times as much of this form of energy as the temperate sun. Modern civilization has used a great deal of this form of energy to aid its development. Believing it had unlimited supplies it has wasted more than it has used and is now making strenuous efforts to conserve the remaining supplies nearest at hand. This is good economic common sense and every effort possible should be made to encourage the better conservation of our forests, but the damage has been so great that long before we can bring them back to proper management, many of our industries will suffer. Our nearest source of outside supplies is the American tropics. Hence the need of investigations along the lines suggested above.

The economic conditions associated with the exploitation and cultivation of tropical forest products are admittedly not the best. The people of our modern civilization have a fear of the tropics. Their Simian ancestors were held in bondage by them until climatic changes forced them to change their habits. Modern civilization in its development has brought under control many of the forces of nature of the temperate regions of the world. It is only when it felt the need of products which it could not find near at hand that it has gone into the tropics.

After all, the dangers of the tropics is not so much in the climate as such, but in the diseases that it breeds. The sanitation work done in the building of the Panama Canal alone proves this. There have been many other less advertised cleaning-up operations on not so large a scale that strengthen the proof. Witness the work done by colonial governments in sanitation, the Americans in the Philippine Islands, the British and Dutch in many parts of the tropical world. Very significant is the work accomplished under the Brazilian govern-

ment in making sanitary the principal cities that were subject to serious outbreaks of yellow fever and other diseases. Many private concerns, realizing that success on a large scale could not be obtained, have their physicians and sanitary engineers. The Rockefeller Foundation has undertaken the task of making yellow fever a historical disease and has done much work in many parts of the tropics in controlling other diseases, such as malaria and the hook worm. This work shows conclusively that nature's forces in the tropics can be controlled, and the day is at hand when the economic resources of the forests can be more fully utilized to serve our increasing wants.

Notes on Science in America

Abstracts of Current Literature

Prepared by Edward Gleason Spaulding, Professor of Philosophy, Princeton University

FACTORS CONTROLLING DISTRIBUTION OF FOREST TYPES

MR. G. A. PEARSON, Forest Examiner of the Fort Valley Forest Experiment Station, presents in two extensive papers published in *Ecology* for July and October, 1920, an account of his investigations on Factors Controlling Distribution of Forest Types. The following is a summary of Mr. Pearson's results and conclusions:

1. Air temperature in the San Francisco Mountain region decreases rather uniformly with a rise in altitude excepting for local inversions in the minimum which occur between the yellow pine and the Douglas fir types, due to air drainage. The lowest absolute minima and the shortest frostless season occur in the yellow pine type, following closely by the alpine type. The highest temperatures and greatest duration of high temperatures are found in the lowest altitudes. Maximum temperatures decrease uniformly from the lowest to the highest stations. The daily range is greatest in the lower altitudes, decreasing from about 50° F. in the pinon-juniper to about 20° F. in the Engelmann spruce. From the Engelmann spruce type to timber line there is a noticeable increase in range due to the exposed situation of the timber line station.

2. Precipitation increases rapidly with altitude up to the Douglas fir type. From the Douglas fir to the Engelmann spruce type it remains almost stationary, but at timber line there appears to be a substantial increase.

3. Wind movement is normally greatest in the higher altitudes, but this relation is not always indicated for the reason that some of the stations are located in the forest while others are in the open. The highest records are obtained at timber line, and the lowest in the spruce forest.

4. Evaporation records show no constant relation to altitude, because wind movement and exposure to sunshine, two of the strongest factors influencing evaporation, vary at the different stations according to density of cover. The highest records obtained are in the pinon-juniper type, and the lowest in the Engelmann spruce type.

5. On the basis of origin there are several general soil types in this region. Those in the pinon-juniper type are derived from sandstone, limestone and basalt. In the yellow pine type local areas of limestone and sandstone occur near the lower limits, but basaltic soils predominate over the type as a whole. Above the yellow pine type all the soils are derived from volcanic rocks.

Probably the most important soil character to be dealt with in this region is the capacity for absorbing and delivering moisture as determined by permeability, water holding capacity, and wilting coefficient. From this standpoint the heavy clay soils common through the yellow pine type present the least favorable conditions for growth, particularly with respect to natural reproduction. Although these soils have a high water holding capacity, they also have a high wilting coefficient, and unless mixed with a large proportion of stone and gravel they are exceedingly impervious. High precipitating, low evaporation, and a high degree of permeability tend to create a large moisture supply in the Douglas fir and Engelmann spruce and alpine types.

Soil temperature is of importance mainly through its indirect effects. When the soil temperature falls to 32° F. or even a few degrees above 32°, the soil moisture ceases to be available to plant roots. If this condition persists continuously over long periods during which transpiration is favored by sunshine and wind the result may be fatal to a tree which is unable to endure extreme desiccation.

6. The data obtained indicate that the upper limits of all the forest types are determined primarily by low temperature as related to photosynthesis, and that the lower limits are determined primarily by deficient moisture supply. Low soil temperature, by rendering the soil moisture unavailable to the roots, may under certain conditions as at timber line become the upper control; but, at least as far as reproduction is concerned, this is not believed to be a prevalent factor in this region, for the reason that in the high altitudes, the only places where long periods of continuously low soil temperature occur, transpiration in seedlings is reduced to a negligible quantity by a deep snow cover. Deficient moisture rather than high temperature is regarded as the lower control because observations supported by experimental data on nearly all of the species in this region indicate that when adequately supplied with moisture they are capable of enduring high temperature far in excess of those which occur at the lower limits of their natural range.

FORECASTING HURRICANES

ONE of the most troublesome features of the hurricane, from the meteorologist's point of view, is that the main part of its course lies over water, and, since ships make every effort to escape the storm, the forecaster is left in utter darkness as to the exact location of the disturbance and its direction of movement. For this reason, it is necessary to utilize whatever observational data can be obtained along the coast. Dr. Cline, of the New Orleans office of the Weather Bureau, has recently stated his belief that the tides are a reliable criterion of the direction of motion of the hurricane while a considerable distance at sea.

Dr. Cline, after a brief mention of the wave-producing powers of winds, takes up all the hurricanes which occurred between 1900 and 1919. In their chronological order, he points out the relations existing between the tides at various Gulf stations, and the position of the hurricanes in the Gulf. He is enabled by these studies to show the portion of the storm in which the greatest wave-producing winds occur.

Dr. Cline has given a diagram of the type of waves and swells which emanate from a hurricane, and he finds that the greatest waves are produced in the rear right-hand quadrant of the storm and travel forward through the storm and make themselves felt far in front and mostly to the right side of the line of advance at the time the wave left the storm. These waves travel in the direction of the storm's motion. Waves of lesser amplitude are sent out to the right and left of the center of advance of the storm in the front half; still smaller, weaker waves are sent out to right and left in the rest of the storm; and, finally, the weakest waves of all are sent out in the rear.

It appears that as these waves begin to reach the coast there is a piling up of water, which is, of course, in excess of the normal predicted tide. By carefully noting and comparing the high water at various stations it is possible, Dr. Cline believes, to detect changes in direction of movement of the disturbance. As an example of this, and also of the fact that the rise of water preceded any change in the barometer, he cites the case of the storm of September 11-14, 1919, in which the "barometer at Burrwood, New Orleans, Galveston and Corpus Christi was either stationary or falling only a few hundredths of an inch, the water, first at Burrwood, later at Galveston and then at Aransas Pass was rising in feet, telling the story of the movement and of the change in the course of the storm as plainly as could be told."

By this method it is possible to tell whether the storm is shifting its course to right or left by the shifting of the point of greatest rise to right or left. The regular tides are not obscured by these storm tides except perhaps in the last twelve hours before the storm strikes, when there are other features of prognostic value which can be relied upon. The highest water occurs a few miles to the right and at about the time of passage of the center and high water is observed from 100 to 200 miles to the right of the storm, while to the left it is hardly observed at all.

The apparent simplicity of this method of forecasting hurricanes must not be overestimated, however. The hurricane is a capricious disturbance and difficulties may be introduced by its unusual conduct either with respect to its rate of movement or point of recurving. An example of this may be made in the hurricane of September 21-22, 1920. This storm, as indicated by the tides after it entered the Gulf, was moving in the direction of the coast between Corpus Christi and Galveston; but it recurved and with unexpected speed swept northward and inland near Morgan City, La.—Abstract from *Science*, December 31, 1920. Article by C. LeRoy Meisinger.

THE TOXICITY OF SALTS TO FISHES

It is well known that bodies of water become uninhabitable for some of the most valuable food fishes, both through natural causes and contamination. Certain investigations indicate that the conditions and the reactions of the water have more to do in determining the habitability of a body of water for food fishes than other factors, such as the availability of food. Shelford has shown that fish do not always occur where their natural food is most abundant. It has been shown by reaction experiments that fishes generally avoid injurious substances which they encounter in nature. But the avoidance of injurious substances which do not generally occur under natural conditions is not so marked. In fact, fishes may react positively to such substances.

Leibig's law of minimum, as it is generally stated, "The yield of any crop always depends on the nutritive constituent which is present in minimum amount," can be applied in a modified form to the habitability of a body of water by fishes; *i.e.*, the presence of any one substance may render a body of water uninhabitable for a species of fish. But as Livingston has stated, "This principle is still quite incomplete logically and its statement will assuredly become more complex as our science advances." The deleterious effect of a substance may depend on the stage of the life-history of the fish, whether it be the developing egg, a young and rapidly growing fry, or an adult. In any of the free moving stages of the life history the effect of the injurious substances may become more sensitive or less sensitive and thus react more definitely or less definitely to any environmental factor. At all stages of the life-history of a fish a deleterious substance may become injurious more rapidly under one set of conditions than under another; or, under still others, it may not be injurious. One of the environmental factors which determine the rapidity with which a substance becomes fatal is temperature. The temperature effect, however, may not be so simple, since the content of the water itself is determined by the season of the year, temperature, light, etc., and the fishes themselves probably have seasonal variations.

All these facts have an important bearing on the problem dealing with the fish in relation to its environment.—Abstract from article by E. B. Powers in *Ecology* for April, 1920.

ANATOMICAL REDUCTION IN SOME ALPINE PLANTS

Mr. C. C. Forsaith contributes to *Ecology* for April, 1920, an interesting article on Anatomical Reduction in Some Alpine Plants.

The material described by the author was collected during the latter part of July, 1919, on the Presidential Range in New Hampshire. The species chosen for investigation represent the well-known gnarled and twisted "Krummholz" growth characteristic of alpine regions. The specimens were secured from sheltered pockets on the lower slopes of the cones and near the upper limits of shrubs.

Examining the several environmental factors, Mr. Forsaith says that the high acidity and sterility of the soil in which these species grow has been caused in large part by water which, leaching through from the upper slopes, has carried away the constituents normally present in other soils. In addition to such a diminution of the organic content, the water has washed away much of the inorganic substance so that plants are often forced to live practically upon bare rock, or at best upon a thin stratum of coarse earth. Besides a poverty-stricken soil, the plants must contend with the rigors of an arctic climate.

The relative humidity as registered at the base and summit of the mountains shows little variation, and doubtless has little influence in the development of a specialized flora.

The especially high wind velocities are very important environmental factors. In addition to being intense, the wind comes in gusts, which causes abrupt changes in pressure as well as snapping and twisting strains in the plants.

The final factor in the environmental series is rainfall. Although the yearly aggregate is equal to that of any other locality east of the Mississippi and far above the average of 44 inches, very little of the water is available for the use owing to a rapid run off from the steep rocky slopes.

Examining three species, *Betula alba*, *Alnus Crispa* and *Rhododendron lapponicum*, Mr. Forsaith finds that all three have shown a marked similarity in their development, and consequently that one seems justified in assuming that a uniformity of cause has produced like results. All have suffered reduction in the storage tissue, and in addition all seem to have followed the usual trend of evolution in their respective genera. Furthermore, they appear to have progressed farther in many cases than have their low-land kin, and may therefore be regarded as high types.

Inquiring more closely into the environmental forces which doubtless have been responsible for progression in alpine plants, the author finds that the chief method of control, exerted by temperature, seems to have been as a gage for metabolism, which in its turn has determined the pace of progression. Physiological studies relative to the effects of heat upon growth have shown that there is a very definite affiliation with the rate of production, and that the rapidity of assimilation of carbon dioxide is practically doubled for every 10° C. within certain limits. It is no small wonder, therefore, that an alpine habitat has been the cause of alterations in structure which are generally manifest in the conservation system as shown in the diminution of the ray mechanism in the alpine birch, alder and lapland rosebay.

That this process of curtailment in the storage tissue is indicative of progress is shown by similar phenomena in closely allied species among the catkin bearing plants. Such an assumption is further strengthened by the retention of broader rays about the conservative leaf trace and traumatic tissue in *Betula cordifolia*, and by appearance of compound rays in the region of the foliar strands in alpine rhododendron even after they have disappeared from other portions of the axis.

In contrast to such simplification in plants from high, bleak mountains, *Alnus nitida* shows that a species growing under more beneficial surroundings has had a marked tendency to increase its storage organization in order to conserve the excess of food brought down from the leaves. The much elaborated aggregate rays in the Himalayan alder shows that such has been the case, and that semi-tropical surroundings have been instrumental in augmenting the parenchymatous areas.

In contrast to this type of development, a cold, hostile climate in alpine regions has through a reduction of the nutrient materials available for growth forced the plants indigenous to high altitudes to undergo radical changes in the fight for existence. In the light of genetic sequence, therefore, such an evolution may be considered as progressive, and on this account species growing in such regions may be classed as high types among their close kindred living in the more sheltered valleys.

Research Work of the United States Bureau of Standards

Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

NATIONAL SAFETY CODE FOR THE PROTECTION OF THE HEADS AND EYES OF INDUSTRIAL WORKERS

THREE years ago the Bureau coöperated with the War and Navy Departments in preparing a set of safety standards to be applied in government establishments. Among these standards was one for head and eye protection and this has formed the basis of the code mentioned above. The rules originally laid down have been further developed by study and experimental work at the Bureau and conferences have been held with many individuals and firms who have had experience in protection of this sort.

Preliminary drafts have been issued and comments received from all sections of the country, so that the present Code may truthfully be said to incorporate the latest and best ideas on this important question. No attempt has been made to specify any particular style or strength of safety goggles or other appliances, but rather to indicate and classify the character of the hazards which exist in the different industries, leaving each employer or officer in charge of safety work to assign to these different groups his own particular industrial operation. The various processes have been divided into nine groups according to the degree of hazard, or because the peculiarities of the operation require a protecting device having certain distinct properties. These groups cover many different operations, from the handling of molten metal to exposure to harmful radiations.

THE THIRTEENTH ANNUAL CONFERENCE ON WEIGHTS AND MEASURES

EACH year there is held at the Bureau of Standards a conference of weights and measures officials from every section of the country. Many representatives of manufacturers and other persons interested in the formulation and enforcement of weights and measures laws are also present, so that the conference may be said to truly represent all those concerned with the use and enforcement of standards of weight and measure in the United States.

The thirteenth conference which was held last spring is described in Miscellaneous Publication No. 43 of the Bureau of Standards. The publication is a verbatim report of the proceedings and contains addresses by the Secretary of Commerce, the President of the Conference, and reports of delegates representing the various states, concerning conditions within their jurisdictions. The subjects treated include: Gasoline pumps from the standpoint of safety; the employment of net weight in sales; the standardization of containers for foodstuffs; weights and measures education in the schools; machine measurements for drygoods, and the resolutions adopted by the Conference.

The report of the Committee on Specializations and Tolerances which was devoted to the subject of liquid measuring devices is also given, as well as the discussion concerning the various provisions. The appendix gives the complete specifications and tolerances for liquid measuring apparatus.

THE EFFECT OF REPEATED REVERSALS OF STRESSES ON DOUBLE REINFORCED CONCRETE BEAMS

WHEN the United States was called upon to greatly increase the size of its merchant marine, owing to the war emergency, it became necessary to construct vessels in the shortest possible time and from various classes of materials. It was considered desirable to attempt to build some of these vessels from reinforced concrete and the way in which this work was carried out is now familiar to most people through the articles which have appeared in the technical press.

The extensive investigational work which necessarily preceded the construction of such vessels has not been so fully described. In order to build a concrete ocean-going vessel, it was necessary to subject the concrete to much higher stresses than are considered allowable in building operations; otherwise the walls of the vessel would have been so thick that its carrying capacity would have been greatly reduced and its dead weight increased to a prohibitive figure.

In connection with the production of concrete ships, the Bureau was called upon by the Emergency Fleet Corporation to make a complete investigation of the effect of a large number of reversals of stresses in double reinforced concrete beams. The investigation covered a considerable period and the complete results have only recently been published for general circulation, as Technologic Paper No. 182 of the Bureau of Standards.

The paper first of all describes the nature of the tests, which were designed to simulate to some extent the effect produced upon a ship by the action of the waves. These cause an alternate upward and downward deflection of the material of which the vessel is built; this action being known among nautical men as "hogging" or "sagging." The specimens used for the test were concrete beams with reinforcement both in the top and bottom. The beams were 4 x 6 inches in cross section over-all and were tested with a span of 8 feet. The load was applied at two points, each 6 inches from the center of the span. It was applied at the rate of about 17 cycles per minute, each cycle including one upward and one downward application of the load. By means of a system of levers, the dead-weight used for the load was multiplied ten times at the beam. The loading mechanism was driven by an electric motor acting through a walking beam. Four beams were tested to failure and a fifth was loaded alternately through 2,000,000 cycles, after which the test was discontinued, although the beam did not appear to be approaching failure.

In the case of the four beams on which the tests were completed, failure was by tension in the steel and, generally, the beams showing the highest stresses withstood the smallest number of repetitions. However, even the largest number of repetitions was so small that failure in the steel would not have been expected as the observed stresses were very low. Other factors than the intensity of the tensile and compressive stresses evidently had a part in bringing about the early tension failure. All the tension failures in the reinforcing bars

occurred at sections where large cracks extended entirely across the section of the beams. It is possible that in some cases the bending at these cracks was sufficient to make the bending of the bar an important factor in causing failure. This tendency was probably accentuated by the slipping of bars at the ends which occurred with one of the beams and was accompanied by the opening up of wide cracks. The presence of gage holes in the bars apparently had some influence in hastening tension failure, but the nature of this influence was not very distinct. The quality of steel used for most of the reinforcement was poor and this would contribute to bringing about an early failure although it does not alone account for the small number of repetitions of stress which were withstood in these tests.

After 7,000 cycles of load, the slip at the end of the bar in one of the beams was less than 1/1000 of an inch, that is, less than the amount which has been taken as the criterion of safe conditions based on tests of the bond resistance between concrete and steel; yet after 400,000 cycles of load, the amount of slip had increased so much that failure by slipping of the bars seemed imminent. In all probability, had not tension failure intervened after an unexpectedly small number of repetitions of load, bond failure of this specimen would have occurred.

GYPSUM—PROPERTIES, DEFINITIONS AND USES

A RECENT circular of the Bureau of Standards has been issued on this subject and may be summarized as follows:

Gypsum is a soft white rock, usually occurring in beds. Other varieties of the same material are known as gypsite and alabaster. It is of common occurrence throughout the United States. Chemically it is a calcium sulphate combined with water. Anhydrite is a variety which contains no water.

Raw gypsum is used for the manufacture of portland cement and as a fertilizer.

Calcined gypsum is made by heating raw gypsum in a kettle until the first evolution of water has ceased. It contains one-fourth as much water as the raw material. This product is frequently known as plaster of paris and is used either as such or as the basic ingredient for the manufacture of wall plaster, potters' plaster, dental plaster, etc. Large quantities of it are used in the manufacture of portland cement, plate glass, and cold-water paints.

When calcined gypsum is mixed with water, it sets to form a hard mass. The time required for this reaction can be varied at will by the addition of suitable retarders or accelerators.

Neat gypsum plaster is calcined gypsum to which has been added some material (such as hydrated lime) to improve its working quality, and the proper amount of retarder. Gypsum sanded plasters are mixed with sand ready for use. Any of these plasters may or may not be "fibered" with either hair or wood fiber, and a special wood-fibered gypsum plaster is made to be used without sand.

Gypsum plasters have excellent fire-resistive ability. The raw gypsum can be heated until all of the water is given off. The product so formed sets more quickly than calcined gypsum. It is not marketed, but is used at the factory to make such products as gypsum tile, gypsum plaster board, gypsum wall board, etc.

Further heating of the raw gypsum forms a material which sets very slowly. An accelerated variety of this is marketed as Keene's cement.

Gypsum tiles are factory-made building blocks. They come in a great variety of sizes, either plain or reinforced. They are used for building walls and roofs.

Gypsum plaster board consists usually of a sheet of set gypsum plaster between two sheets of unsized paper. It comes in many sizes, usually about 3 feet square by ⅜ inch thick. It is used instead of lath as a backing for plaster.

Gypsum wall board is of about the same construction as gypsum plaster board, but the paper is sized so as to furnish the finished surface of the wall. It comes in strips 4 feet wide by any length from 6 to 14 feet, by 5/8 inch thick.

The Bureau is coöperating with the Gypsum Industries Association in research work on this subject, and the Association has established a fellowship at the Bureau.

Recommended specifications for calcined gypsum, neat gypsum plaster, gypsum plaster board, and gypsum wall board are given in full, for which the original paper should be consulted.

DETERMINATION OF THE STANDARD FOR "WHITE LIGHT"

THE definition of "white light" naturally constitutes a very important part of the scientific foundation of colorimetry. If we consider incandescent light sources generally (including oil and gas flames; carbon and metallic filament electric lamps) we find that the light from sources at comparatively low temperatures evokes reddish or yellowish colors. As the temperature of the source increases, the color becomes paler and paler yellow and, at higher temperatures, approximates to "white." However, all artificial incandescent sources are decidedly yellow in comparison with sunlight, since it is not possible to operate an artificial source at a sufficiently high temperature to color-match sunlight. We are led to anticipate, however, that a source at a sufficiently high temperature would color-match sunlight, and further that sources of still higher temperatures would appear blue relative to the sun. The question arises as a matter of physiological optics at what temperature would a source appear under standard conditions of observation neither blue nor yellow but white? The further question then arises relative to this standard, is the sun blue, yellow or white? Recent experiments made at the Bureau answer these questions in so far as four observers are concerned. They are the first accurate experiments of this nature ever performed. The answers are:

(1) Theoretical. The temperature which a hypothetical source would have in order that its light might evoke the sensation white (the hueless sensation of brilliance recognized as neither bluish nor yellowish) would be about 5,200 degrees absolute Centigrade.

(2) Practical. The light of the average noon sun at Washington evokes a sensation closely approximating white.

These experiments and their results were describel at a joint meeting of the American Physical Society and the Optics Society of America in Chicago, December 29, 1920. It is expected that they will be described in detail in a forthcoming publication of the Bureau of Standards.

INVESTIGATIONS IN ELECTRONICS

Two general types of inelastic impact between an electron and an atom may occur. The first of these results in an orbital shift of the electrons bound in the atom, and the second in the complete removal of an electron or ionization of the atom. The respective potential differences through which an electron must fall to acquire sufficient velocity for these two types of collision to occur are known as the resonance and ionization potentials for the particular metal in question. The determination of these constants has been continued. Work of this character is of theoretical interest from the standpoint of pure physics, and of practical interest in that it furnishes further evidence toward an explanation of the phenomena of ionization and related problems which arise in the design of vacuum tubes for wireless telephony and telegraphy, rectifiers, etc.

Two scientific papers entitled "Ionization and Resonance Potentials of Some Non-metallic Elements," Scientific Paper No. 400, and "Resonance Potentials and Low Voltage Arcs for Metals of the Second Group of the Periodic Table," Scientific Paper No. 403, respectively, have been published. The first of these gives data for phosphorus, while the second gives data for zinc, cadmium, mercury, magnesium, and calcium, with predicted data for strontium and barium.

Research Work of the U. S. Bureau of Forestry

Notes from the Forest Products Laboratory at Madison, Wisconsin

LUMBER USED IN THE MOTOR VEHICLE INDUSTRY

THE rapid increase in the proportion of closed cars manufactured is an outstanding feature of the automobile industry. An official of a large company recently expressed his belief that in five years one-half of their output would be closed cars. Already one out of every eight pleasure cars of a well-known make is a sedan or coupe. This means a large consumption of lumber, as the closed car takes from two to three times as much lumber as an open car, and a better grade of lumber is required to insure rigidity and freedom from warping in the closed body. An engineer of the U. S. Forest Products Laboratory, Madison, Wisconsin, recently visited a number of manufacturing plants to determine what woods are now being used in the automobile industry, to what extent substitution of one species for another is taking place, and what troubles manufacturers are having with wood. He found that maple leads for use in the construction of bodies, elm is next, and ash is third. More 2- and 3-inch stock is used than thinner materials. The following comments are to be noted in connection with the use of various woods:

Maple.—At most of the plants visited by the representative of the Forest Products Laboratory, maple was used for body sills (in one plant practically the entire framework and even the floor boards of the car were made of maple), although ash is used for sills at some of the plants. Maple is cheaper, and is generally more uniform in quality than ash, and warps less than elm. In one plant birch was suggested as a substitute for maple, but it is more expensive. Maple is said to hold screws less rigidly than elm because it is less fibrous and after use the screw hole becomes enlarged and smooth, permitting the screw to come out easily. One company preferred birch to maple in sedans because they claimed it would take and hold varnish better, especially on rounded corners. Maple was also said to split more easily than elm, making it difficult to saw curves with economy.

Elm.—Elm seems to be the principal wood used for the framework of open bodies. Soft elm is used except for the trim rails, which are of rock elm or a good grade second-growth soft elm bent to proper shape. Soft elm works easily, holds screws well, and does not split easily. Stock up to 4 inches in thickness is used.

Ash.—Ash was formerly used almost exclusively in automobile work, but due to its greatly increased cost it is now used only on high priced cars, and on cars with closed bodies which command a relatively high price. Ash is preferable for use in framework of closed cars because it holds its shape well. At one plant trouble was experienced with maple as compared with ash and this made the cost of maple equivalent to that of ash. A tough sill is required to reinforce the steel frame. That the wood actually reinforces the steel frame is shown by the fact that breaks in the frame usually occur at the front end of the wood sills, that is, near the dash.

Birch.—The use of birch is probably increasing in automobile manufacture. Some manufacturers report its use in sills and frames. It is preferred to maple on exposed painted parts because it is said to hold the paint better. It is said to be as good as maple as far as mechanical properties are concerned and better in seasoning properties, but usually it is slightly more expensive.

Hickory.—This species is used for spokes and rims only.

Gum.—An appreciable quantity of red gum is used for various parts, such as foot risers, foot boards, strainer slats, and floor boards. It has been used for frames and steering wheels.

Other Species.—Among the other species used for minor parts of automobiles are the following: Wormy oak is used for running boards, floor boards, and foot boards and foot risers. For top bows second-growth, at least so-called second-growth oak is used principally, although some elm is now used. Sycamore is used to some extent for posts and pillars. Yellow pine is used for floor boards and running boards. Douglas fir has been used for the same purpose as yellow pine. Basswood, cottonwood, and yellow poplar are used for minor parts.

Table 1 shows the kinds of wood used in the different parts of an automobile, based on a study of these companies which made bodies for a number of automobile manufacturers.

Table 1.—*Kinds of Wood Used in Open Cars*

Sills, longitudinal and cross	Ash, hard maple, and occasionally elm, red gum, magnolia and soft maple
Floor boards	Sound and wormy oak, hard and soft maple, red gum, beech, wormy chestnut, elm
Seat risers, or "heel boards"	Hard and soft maple, red gum, yellow pine
Seat boards, or seat frame	Hard and soft maple, red gum, and numerous other species
Seat lids	Maple, gum, elm, and numerous other species and plywood
Pillars and posts	Hard and soft maple, ash, elm, sycamore, and red gum
Seat rails (arms and back)	Ash, elm, and maple
Strainer slats, or "spring slats"	Maple, ash, and gum
Doors	Hard and soft maple, ash, and elm
Trim rails	Rock elm
Running boards	Wormy oak, yellow pine, maple, Douglas fir
Steering wheels	Walnut, maple, red gum
Spokes	Hickory
Rims ("felloes")	Hickory
Top bows	Oak
Dash	Cottonwood and maple

It is estimated by the Forest Products Laboratory at Madison, Wisconsin, based on studies made by a member of its staff in recent visits to a number of automobile manufacturing plants, that the total amount of wood used in the construction of automobiles and motor trucks in the United States amounted to 384,751,000 feet b.m. in the year 1919. The total consumption of wood used in the industry is roughly estimated in Table 2.

Table 2.—*Amount of Lumber Used Annually in the Manufacture and Shipment of Passenger Cars and Motor Trucks Based on 1919 Production of Cars*

Total output of passenger cars	1,660,000	
Average number of board feet of lumber used per car	160	
Total lumber used in passenger cars		265,600,000 bd. ft.
Total output of motor trucks	316,500	
Average number of board feet of lumber used per truck, including body	200	
Total lumber used in motor trucks		63,300,000 bd. ft.
Total number of passenger cars exported	66,400	
Average number of board feet of lumber used in export crating of passenger cars	660	
Total lumber used in export crating of passenger cars		43,824,000 bd. ft.
Total number of trucks exported	15,825	
Average number of board feet of lumber used in export crating of trucks	760	
Total lumber used in export crating of motor trucks		12,027,000 bd. ft
Grand total		384,751,000 bd. ft.

The amount of lumber used in each car varies from 75 feet b.m. for a small open car to 200 feet b.m. for a medium-priced touring car. An average given by a large body manufacturing corporation is 140 to 150 feet b.m. for open cars for

each body. A small sedan requires 225 feet b.m. and a large sedan, not including running boards, uses about 310 feet b.m. One company stated that the average waste was about 30 per cent, including drying losses, cutting, and minimum jointer waste, although others place the waste as high as 40 per cent. In automobile work firsts and seconds are used nearly exclusively. One company used 75 per cent first and seconds and 25 per cent No. 1 common. A large body company used 40 to 50 per cent first and seconds, and the rest No. 1 common of maple, elm, and oak. Another company making high-priced cars will take only 20 per cent of No. 1 common.

MANUFACTURE OF ETHYL ALCOHOL FROM WOOD WASTE

Sawdust and shavings are generally waste products in the manufacture of lumber. Where other waste in the form of slabs and edgings from large logs is available, the manufacture of pulp for paper is a desirable method of utilizing waste material; but, if the product is largely sawdust and shavings, the manufacture of ethyl alcohol is probably more economical. There are two general processes for converting wood into fermentable sugar: those using a concentrated acid, and those using a dilute acid under pressure.

The first method depends upon a complete solution of the cellulose in a highly concentrated acid. The resulting products are then hydrolyzed to sugars by boiling with a large volume of water. By this process yields of sugar corresponding to fifty per cent of the dry weight of the wood are obtainable; but the disadvantages connected with the process more than offset the advantage of a high sugar production. The disadvantages are first, the lack of a satisfactory method for the recovery of the acid used, a necessary procedure in view of the large quantity of acid required; and second, the difficulty of constructing apparatus capable of withstanding the corrosive action of the hydrolyzing agent.

The second process is commercially feasible and has been used successfully in this country by two plants for the last few years. It is, however, limited at present to those mills cutting soft woods, since experiments have shown that the yields are about one-third greater from coniferous wood than from the broad-leaved varieties.

This process consists of digesting sawdust, or a mixture of sawdust and shredded mill waste, with dilute sulphuric acid for 15 or 20 minutes at a steam pressure of 115 to 120 pounds. This operation is carried out in a rotating digester lined with acid-resisting brick and results in a conversion of 20 to 25 per cent of the dry weight of the wood into sugars, about 75 per cent of which are fermentable. The sugars thus produced are then removed from the digested material by extracting with water in a diffusion battery similar to those used in the beat sugar industry. The sulphuric acid is eliminated from the sugar solution by treating it with lime or calcium carbonate and allowing the sludge to settle. The settling requires fifteen to twenty hours. The clear solution is then drained off, cooled to the proper temperature, and fermented in much the same way as is cane sugar molasses. The alcohol produced is removed by distillation and rectified in a manner similar to that employed in the manufacture of industrial alcohol from grain, molasses or other materials.

The essential parts of a plant necessary to produce ethyl alcohol from wood, considered in order of their use, are the following: Dust house for the storage of an adequate supply of sawdust; hogs, shredders and screens; sawdust storage above digesters; acid and lime storage and mixing houses; digesters; diffusion battery; neutralizing and settling tanks; coolers; fermenting tubs and yeast equipment; beer still; rectifying still; and bonded warehouse.

For best economy this plant must be operated continuously, and it should therefore have at least a 15-day supply of wood on hand; and where logging operations are such as to require frequent shut downs, the alcohol plant should have sufficient material in storage to tide over. The steam consumption in the plant will be distributed about as follows: Pump, 20 per cent; digester, 30 per cent; hogs and shredders, 20 per cent; general power, 15 per cent; distillation and rectification, about 15 per cent; including exhaust steam.

While it is unfortunate that several early failures occurred in plants using this process, these failures were due to (1) difficulties encountered during the general development of the process because of the lack of experience in the commercial application of such a process; (2) promotional difficulties; (3) lack of technical experts in this field who have the necessary chemical, engineering, and bacteriological skill to develop the operation; (4) difficulties have also been encountered by the erection of a plant at a point where insufficient quantities of wood were available, a condition which naturally interferes with the continuous operation of such a plant.

The fact that two plants have operated successfully in this country for the past few years indicates that the process is commercially feasible. Investigations at the Forest Products Laboratory indicate that after allowing the necessary manufacturing losses, a yield of 20 gallons of 95 per cent alcohol per ton of dry wood is obtainable from the coniferous wood.

An alcohol plant, to be successful, should have a minimum daily production of 1,500 gallons of 95 per cent alcohol. This would require 75 tons of dry wood, or its equivalent, in air-dry or green condition, and comparatively free from bark. A smaller plant than this would increase the distillation and rectification cost to a questionable figure because continued operation would no longer be possible in standard apparatus. Such a plant would cost approximately $250,000 to $300,000 under normal conditions. When conditions permit, however, a larger plant is desirable. The distribution of cost in a plant using 225 cords (180 tons dry wood) a day and operating 24 hours a day of three 8-hour shifts in all departments excepting the digester, lime and acid house, when two 9-hour shifts will suffice, will be approximately as follows:

Item	Cost per gallon of Ethyl Alcohol Produced
Interest, depreciation, taxes, and insurance	$0.046
Raw material, wood, sulphuric acid, lime, fermentation materials, and fuel	0.087
Labor	0.060
Executive salaries, and other overhead expenses	0.050
Total	$0.243

The cost of wood is taken at 50 cents per cord. This is a very low cost of manufacture and it would only hold under conditions outlined.

BETTER CRATING

Boxing and crating has been and likely will continue to be a serious question with all exporters, especially automotive exporters. It is generally admitted that the laxity in crating results from ignorance of the conditions that the package will encounter rather than a deliberate intent on the part of the packer to wreck his merchandise en route.

During the war the munition and other shippers are reported to have accomplished a very good job in the packing. This was done by specifications, based on Laboratory investigations, provided by the Government for the particular job.

Now the laboratory is quite willing to provide a similar service for any packer who may be willing to come to Madison and study the situation. This is arranged in the way of special classes consisting of 12 men each. An intensive six-day course is provided. Classes will be organized on January 10, March 7 and May 2, 1921. A coöperative fee of $100 is required, in addition to each student's paying his personal expenses. The fee goes toward the support of the laboratory.

Application should be made by the firm that is sending the student, as this is not a plan to equip a man to get a job, but a plan to accomplish a definite service to trade generally.—From editorial in *Automotive Industries*, Dec. 16, 1920.

Progress in the Field of Applied Chemistry

Notes Culled from Current Technical Literature

By H. E. Howe, Member of American Chemical Society

FOOD INVESTIGATIONS

THE report of the Food Investigation Board of the Department of Scientific and Industrial Research of Great Britain for 1919 is now available and will be found of unusual interest. There has been a prolonged investigation of the effect of cold storage upon that accessory food factor known as fat soluble (a vitamine), and it is reported that cold preserves this necessary substance completely. This result is of considerable scientific importance as it will make possible the study of the influence upon the quantity of vitamine present in butter or milk, for example, of the diet of the animal and of the season of the year. There has been an extended study of the effect of cold storage upon the food factors of fruits and directly or indirectly on the preservation of food by cold. The report states that so far as is now known there is no agent which preserves the nutritive properties of foods so completely as does cold, at the same time maintaining the food in a condition fit for human consumption. The meat committee has completed experiments upon the freezing of beef and it is remarkable that whereas mutton can be frozen without damage, beef cannot. This is true so far as present methods as practiced by industries are concerned but the new experiments prove that under proper precautions beef can be frozen in a satisfactory manner. Ordinarily freezing alters the muscle substances so that upon thawing a fluid rich in nutritive material exudes.

With respect to the diet of animals experiments indicate that dried blood added in small amounts to the diet of pigs produces a remarkable increase in the rate of fattening.

Attention has also been given to methods of drying fruits and of the respiratory metabolism of fruit at low temperatures. The oxidizing enzymes responsible for the discoloration of certain fruits on injury have also been included in the survey. The chemistry of the ripening processes in fruit with special reference to the changes in the pectin have been investigated and the limits of temperature within which the molds which commonly infest it in storage will grow have been determined.

The reports include certain details with reference to the experiments and results and can be obtained for six shillings from H. M. Stationery Office, Imperial House, Kingsway, London, W. C. 2.

AMERICAN POTASH INDUSTRY

American Chemical Society News Bulletin reports an address by Dr. J. E. Teeple on the present status of the American potash industry. Quoting Dr. Teeple, "In 1918, the banner year, 128 different plants operated, giving a total production of over 54,000 tons of potassium oxide. In 1919, with the fall of the price of potash, this production dropped to about 30,000 tons. Out of the 128 plants reported as producing in 1918, only 43 were reported as producing in 1920. With the price of potash in 1921 still lower than it was in 1920, we may expect a still greater falling off in the number of producing plants, and possibly in the total output.

"We have not reached a point where our cost of production is as low as 75 cents per unit of potassium oxide, which was about the minimum selling price of German potash before the war, but we are beginning to see where we may get within shooting distance of it. It will probably take two or three years yet to work out this problem to a finish, where we are producing potash at Searles Lake in large quantities as cheaply as it can be produced there. When this point is reached I do not think we need seriously fear German or any other competition.

"The two largest items of cost we have at the present moment in production are fuel and freight, and if we can get any kind of ultimate coöperation from the oil producers and from the railroads we will be able to supply a large part of this country's need of potash without any protection. Do we need protection until this work is finished? It is probable that we do. Germany's need of money and goods is a most serious need. There will be a great temptation for her to convert some of her supplies of potash into immediate cash. Probably no potash plant in America could sell this product today at one dollar per unit and cover its cost of production.

"Our experiences hold that where production ceases there is little incentive to keep expending money on research and development work. Prices of potash during the past year have averaged close to $150 per ton of potassium chloride. On the basis of our average consumption, this represents close to $60,000,000. Before the war this would have represented around $20,000,000. The size of either figure makes it well worth while to encourage the growth of such an industry in this country, since apparently it has every prospect of being able to live alone and do its own fighting, once its development period is over."

REORGANIZATION OF SCIENCE IN SECONDARY SCHOOLS

THIS is the title of Bulletin, 1920, No. 26, Department of the Interior, Bureau of Education, and affords some interesting observations on the necessity for reorganization and the advantages to be gained from the pursuit of science in our secondary schools. The principal aims in teaching chemistry in the high schools are given as follows:

"1. To give an understanding of the significance and importance of chemistry in our national life. The services of chemistry to industry, to medicine, to home life, to agriculture, and to the welfare of the nation, should be understood in an elementary way.

"2. To develop those specific interests, habits, and abilities to which all science study should contribute.

"The powers of observation, discrimination, interpretation, and deduction are constantly called for in chemistry and are so used in this subject as to require a high type of abstract thinking. The principles and generalizations of chemistry are often difficult. For this reason chemistry should occur in the third or fourth year of the high school.

"3. To build upon the earlier science courses, and knit together previous science work by supplying knowledge fundamental to all science. Coming after at least a year of general science, and usually also a year of biological science, the work in chemistry should further use these sciences. It should furnish a new viewpoint for the organization of science materials, and develop wider and more satisfactory unifying and controlling principles. By this means the desirable element of continuity in the science course will be secured.

"4. To give information of definite service to home and daily life. This aim has been the chief influence in reorganizing high-school chemistry courses, and will undoubtedly produce further changes. The criterion of usefulness, as a basis for the selection of subject matter, should not be limited to the immediately useful or practical in a narrow sense, but should be so interpreted as to include all topics which make for a better understanding of, and a keener insight into, the conditions, institutions, and demands of modern life.

"5. To help pupils to discover whether they have aptitudes for further work in pure or applied science, and to in-

duce pupils having such aptitudes to enter the university or technical school, there to continue their science studies."

Subjects toward which some of the pupils should be directed include the atmosphere as a sample introductory topic, purification of water, a study of lime stone, lime and allied products, simple inorganic preparations having to do with materials of every day acquaintance, and introductory courses in household or domestic chemistry, in chemistry for nursing, for electro-platers, for pharmacy, and in technical curricula special courses for those who may become workmen and foremen in the chemical industries. This is important since in many centers manufacturers permit their employees to study in technical high schools one hour a week in order to increase their productivity and efficiency.

ILLUMINATING AND HEATING GAS FROM WOOD

Chemical and Metallurgical Engineer, January 19, gives the following note on this subject:

"The industry of manufacturing illuminating and heating gas from wood distillation has made rapid progress in Switzerland during the last few years. The disadvantages of wood gas (presence of great quantities of acetic acid, which is harmful to the life of the pipings, and of carbon dioxide) have been greatly reduced by the use of an improvement in wood distillation which consists in passing the gas through incandescent charcoal. The consumption of charcoal is from 1 to 3 kg. per 100 kg. of wood or 3 to 6 kg. per 100 cu. m. of gas. Tests have shown that by this improvement the following results are obtained as compared with those for a simple distillation of the wood:

"The amount of gas produced from a given quantity of wood is nearly doubled.

"The carbon dioxide content is reduced 25 per cent.

"The calorific value of the gas is reduced 22 per cent.

"The heavy hydrocarbon content is reduced about 66 per cent.

"The methane content is reduced 50 per cent.

"The hydrogen content is increased 80 per cent.

"The tar content is decreased 50 per cent.

"The acetic acid content is reduced to a practically negligible quantity. The apparatus and pipings are not deteriorated by these small quantities of acetic acid.

"The gas produced is much lighter.

"The water content of the tar is greatly reduced, thus improving its selling price."

GEOPHYSICAL CHEMICAL PROBLEMS

IN the Proceedings of the National Academy of Sciences, Vol. 6, No. 10, much space is devoted to a discussion of research problems in geophysics and in it is included an interesting section on the problems of geophysical chemistry by Dr. R. B. Sosman.

Dr. Sosman points out that 98 per cent by weight of the outer ten miles of the lithosphere is made up of the common oxides and that all the other elements and compounds are known to chemistry and included in the remaining two per cent. These abundant oxides are gives as follows:

SiO_2	About 60 per cent by weight
Al_2O_3	About 15 per cent by weight
FeO Fe_2O_3	About 6 per cent by weight
CaO	About 4.9 per cent by weight
MgO	About 3.7 per cent by weight
Na_2O	About 3.3 per cent by weight
K_2O	About 3.0 per cent by weight
H_2O	About 2.0 per cent by weight
CO_2	About 0.7 per cent by weight

The study of these oxides and their combinations is essential to the progress of petrology and such research must proceed from the simple individual oxide to two and three component systems to still more complex bodies. The study of the systems may be divided into (1) investigations of the anhydrous oxides of silicates in the first eight oxides of the list quoted, and (2) investigations including hydrous silicates. Researches are called for not only on the chemical substances of the earth's surface but also upon the aggregates which include the igneous rocks, the pyroclastic and sedimentary rocks, the oceans and other bodies of water, and the atmosphere.

GLASS COLORS

SCHNURPFEIL'S Review for Glass Works, 4, 685 (1920), gives the following table relative to the normal color for the ordinary coloring oxides in the kinds of glass indicated and this note is from an abstract appearing in the *Journal of American Ceramics:*

Metal oxide	Lead glass	Potash glass	Soda glass
Silver oxide	....	Yellow or orange	Yellow or orange
Chrome oxide	Greenish red	Greenish yellow	Grass green
Cobalt oxide	Pure blue	Blue	Bluish violet
Copper oxide (red oxide)	Blood red	Purple	Purple (yellowish)
Copper oxide	Green	Sky blue	Sky blue (greenish)
Ferrous oxide	Greenish yellow	Bluish green	Bluish green
Iron oxide	Greenish yellow	Bottle green	Bottle green
Manganese oxide	Amethyst	Bluish violet	Reddish violet
Nickel oxide	Bluish violet	Amethyst	Yellowish violet
Purple precipitate of cassius (gold)	Red or rose	Red or rose	Reddish blue
Uranium oxide	Topaz	Siskin yellow	Greenish yellow
Sulphur, carbon	Black	Golden yellow	Pale yellow
Antimony oxide	Orange (opaque)	....	....
Selenium	....	Pink	Salmon color
Tin oxide	Enamel white	White	White

METHODS OF WATER PURIFICATION

IN the January 19th issue of *Chemical and Metallurgical Engineer* there is an excellent article on "A Comparison of Various Methods of Water Purification." The author, W. M. Taylor, divides the purification of water for industrial purposes into five classifications:

"Distillation.

"Removal of suspended matter by filtration.

"Water-softening by filtration through zeolites.

"Water-softening by precipitation.

"Rectification by the use of boiler compound."

There is a general discussion of these various methods of water purification and the general summary is quoted as follows:

"For laundries, textile mills, dyeing plants, manufactories of chemicals, extracts, etc., the quality of whose products is lowered by the presence of calcium or magnesium salts, the zeolite water-softener is preferable if the raw water is such that the zeolite water-softener can handle it and if the presence of sodium salts in the water has no injurious effect.

"If the water for the above industries cannot be handled by a zeolite water-softener, treatment by the precipitation water-softener will usually prove economical and valuable.

"For the manufacture of raw-water ice, the precipitation water softener is the only satisfactory method of treating.

"In larger installations, with an average hard water, which shows no tendency to foaming or priming, for fire-tube boilers, the precipitation water-softener produces the best results.

"In smaller installations, or with a low hardness, or an extremely high hardness, for fire-tube boilers, properly prescribed compounds are preferable.

"For water-tube boilers of any size and for locomotives boiler compounds usually show best results.

"Where high amounts of sodium salts predispose the water to foaming and priming, boiler compounds give best results.

"In cases of electrolytic corrosion, the use of a zinc-bearing boiler compound will frequently correct the trouble.

"From the above conclusion it is apparent that each type of water purification has a fairly well-defined field in which it is unquestionably *best*. The fields, however, where either of two different methods of treatment would give good results

are quite frequently met with, and in these cases individual considerations would decide which of the two methods would be better."

ELECTRO-DEPOSITION OF BRASS

A. L. FERGUSON and E. G. Sturdevant are joint authors of a discussion of "The Electro-Deposition of Brass from Cyanide Solutions" which has been summarized in a recent issue of *The Metal Industry*. The summary follows:

"(1) Increase in the ratio of copper to zinc in the solution increases the percentage of copper in the deposit. A solution in which the ratio of copper to zinc is 4.2 gives a deposit of about 65 per cent copper (ratio 1.9).

"(2) Solutions of high metal content are more satisfactory than dilute solutions. A solution containing thirty-five grams of metal per liter, in the above ratio, gives deposits.

"(3) Increase in temperature decreases cathode polarization and consequently increases the percentage of copper in the deposit.

"(4) Increase in current density produces a gradual decrease in the percentage of copper in the deposit. At current densities greater than 0.3 ampere per sq. dm., the deposit becomes granular, non-adherent, and dull.

"(5) Increase in free cyanide does not increase anode efficiency, but does decrease cathode efficiency. Its influence on the percentage of copper in the deposit is variable.

"(6) Slightly acid substances increase the percentage of copper in the deposit. A weak acid may be used in place of any of the acid substances that have been recommended.

"(7) Slightly alkaline substances decrease the percentage of copper in the deposit. The presence of slightly alkaline substances is beneficial in that it improves the appearance of the deposit.

"(8) Neutral substances have no influence on the deportment of the cyanide brass plating solution.

"(9) Brasses which vary in composition from 62.3 to 85.0 per cent of copper dissolve as such anodically. The efficiency of corrosion is about the same as that of copper.

"(10) Decided depolarization of zinc by copper takes place and makes possible the deposition of brass from solutions in which the potentials of the two metals are not equal.

"(11) Electro-deposited brasses which vary in composition from 37.6 to 82.0 per cent copper give nearly the same potentials in a plating solution. These potentials are nearer to that of copper than to that of zinc."

INFLUENCE OF MOISTURE ON THE SHADE OF DYEING

THIS is a title of discussion by J. Rouffin in *L'Industrie Textile*. Dyers have noted that some coloring matters are modified by heat, the shade usually being reddened. Yellows have become shades of orange and the orange shades tend toward scarlet tones. It has also been observed that some coloring matters are not sensitive to heat while with others the sensitiveness is so extreme that final matching must proceed with great caution. It now appears that heat is not the real cause of these changes but that moisture is the important consideration. The following is quoted:

"It appears reasonable, therefore, to suggest that the variation of the shade may be directly due to the hygrometric state of the material. In attempting to verify this hypothesis, samples of woolen felt dyed with different coloring matters were taken and cut each into three parts. One lot was placed in a desiccator holding a vessel of concentrated sulphuric acid, that is, in a dry atmosphere, where the wool would have the moisture taken from it progressively at the ordinary temperature until completely dry. Another lot was placed in a desiccator holding a vessel of pure water, that is, in an atmosphere saturated with moisture, where the wool would absorb progressively, and without being heated or cooled, the maximum amount of water it is able to carry. The third lot was kept in the air of the room.

"The results have confirmed the hypothesis advanced. In the dry atmosphere the colors became modified in the same manner as takes place by drying them in the dry-room. In the moist atmosphere the colors became modified to the same extent as a wet cold pattern. The experiments were repeated with a large number of the acid and chrome dyestuffs for wool, and in each instance the immediate cause of the alteration of the shade was the hygrometric state of the fiber.

"Heat only intervenes as a moisture-removing agent. That the return to the original shade takes place slowly may be explained by the fact that time is required for dried wool to resume its normal hygrometric state. Many coloring matters are very sensitive to heat, some others are hardly affected at all, while others are most profoundly affected."

COLORS FOR STRAW

LOUIS G. HAYES, under the title of "The Dyeing of Straw and Hemp," presents interesting information in the January number of the *Color Trade Journal*. Methods of dyeing are discussed as well as colors best suited for different classes of work. The following applies particularly to straw:

"Basic and acid colors are mainly used for this fiber and the following list of colors which are obtainable today will be found sufficient to produce all the seasonable shades.

"The well wetted material should be entered into the lukewarm dyebath in a warm state as in this condition the natural wax is soft and pliable which greatly aids penetration. The basic colors are dyed with the necessary amount of dyestuff and from 3 to 5 per cent of acetic acid (28° Tw.), depending upon the depth of the shade, and boiled from 2 to 3 hours moderately, after which they are removed from the dyebath and washed.

"The acid colors are handled in the same manner with the exception that the dyeing is started without any acid and it is added in small amounts. The dyeing operation may take a longer owing to the slower drawing power of the acid colors.

"Blacks are produced by a mixture of basic colors in the proper proportions, the color generally used being Malachite Green, Methyl Violet and Bismarck Brown.

"The material should be dried at a moderate temperature. It may be noticed that the basic colors have a light bronziness after drying, but, while objectional, this is entirely removed in the sizing of hot shellac that the hats receive after they are sewn and before they are shaped in the hydraulic processes.

Yellow and Orange

ACID	BASIC
Azo yellow	Auramine O
Tartrazine	Chrysoidine Y, R
Orange II	Brilliant Phosphine
Croceine Orange	
Metanil Yellow	

Brown

Rescorcine Brown R, Y	Bismarck Browns

Pink and Red

Fast Red	Cloth Red
Azo Fuchsine	Safranine
Scarlet 2K	Magenta

Croceine Scarlet MOD

In this class also comes Rhodamine which can be used in conjunction with either class of colors.

Blue and Violet

Fast Blue R	Methylene Blue
Patent Blue	Fast Indigo Blue
Soluble Blues	Methyl Violet
Induline	Crystal Violet
Nigrosines	Acid Violet 4BN
Acid Black 10B	Victoria Violet

Green

Naphthol Green	Brilliant Green, Crystals
Acid Green L	Malachite Green, Crystals."

Progress in the Field of Electricity

Summaries and Excerpts from Current Periodicals

By A. Slobod

THE NEW PORTABLE OSCILLOGRAPH AS APPLIED TO COMMERCIAL WORK

Since the early days of alternating current machines, efforts have been made to get records of actual wave shapes. The rotating contact maker, which momentarily connected a voltmeter to a generator at a controllable point of the wave, was the commonly used device twenty years ago. The result, of course, was rather crude. Nothing in the way of transient phenomena could be investigated by such a device. Duddell is credited with original refinement of the galvanometer to enable it to follow accurately individual waves and transients.

Cumbersome as the early oscillographs were, they permitted the obtaining of hitherto inaccessible data on the electric circuit. The oscillograph has since been greatly developed and its use became so universal that at present no investigation of the general characteristics of an electrical device, by which any alteration of the electromotive force is produced, is complete without the taking of oscillograms.

In the present article Mr. Legg describes a new design of a portable oscillograph and some commercial applications of it. The oscillograph has hitherto been primarily a laboratory instrument, difficult to move and requiring considerable time to set up in a new location. The new oscillograph is readily portable. It is complete in two units. The main case is 14 inches high, 13 inches wide and 25 inches long and contains a housing for an incandescent lamp. Photographic drum and driving head attached to the optical box control switches and ammeter for indicating the field current of the galvanometer. The motor board is separate and carries the induction motor, fitted with stepped grooved pulleys and back gears, the transformer, the lamp control rheostat, the double-throw, double-pole switch for 110- or 220-volt transformer operation and protecting fuses.

The series electromagnet galvanometer is only 7 by 7 by 4.25 inches overall. There are three vibrator elements of a rugged construction. The resistances for the elements, controlled by dials, are wound on thin micarta cards, so as to be nearly non-inductive. One dial gives a range of 0 to 100 ohms, while the other gives a range of 100 to 10,000 ohms. As the element takes about 12 amperes per inch deflection on the photographic drum, it can be seen that the high resistance dial is sufficient to give proper element deflection for peaks as high as 4,000 volts direct current, or 1,500 volts alternating current. By the use of a double set of binding posts, together with a double throw, double-pole switch, the element may be switched quickly from a voltage recording position to a current recording position.

A decidedly novel feature of this new oscillograph is the elimination of the arc lamps and the substitution in its stead of a tungsten filament lamp. This feature will appeal to anyone who has had to operate oscillographs in the past by using the arc lamp with its heat, sputter, necessity of periodical adjustments, etc.

In order to obtain by means of the tungsten filament lamp a light comparable to that of the arc, a voltage greatly in excess of normal is impressed for an exceedingly short period. The lamp does not burn out until thousands of exposures have been made.

In the optical arrangement the novel features are: The focal plane, drum, shutter, and mechanical shutter release, the trip magnet and remote control switch and the lamp extinguishing switch. The double conductor passing to the driving head is in the trip magnet circuit. An adjustable contact, on the driving head, closes this circuit any desired fraction of a revolution ahead of the opening of the shutter. This should be set to equal slightly less than the time which will be required for the remote control apparatus to function. The length of the exposure depends on the speed of the photographic drum. With this apparatus the drum speed may be varied from about twelve hundred to sixty revolutions per minute, giving an exposure of from .05 second to 10 seconds.

For fast films the incandescent lamp is placed momentarily on a 60 per cent excess voltage, which, if continued, would cause the lamp to burn out in less than one second. Either a filament of a very heavy current (18 amperes or more) or a specially constructed ribbon filament is used. With the automatic lamp control of this oscillograph, thousands of films may be taken before burning out the lamp. For slow films which have been taken up to three-quarters of an hour exposure, the lamp needs but slight abnormal voltage.

With the special automatic control of the incandescent lamp and shutter it has been possible to take and develop nearly a hundred films in one day, for no readjustment of the oscillograph is needed when it is once set up for a particular test.

For moderate speed films (of one-half second exposure or over) any number of portable oscillographs can be operated simultaneusly and still be located in different stations and record the different local effects of the same transient started by the remote control switch of one of the oscillographs. The closing of one switch, which supplies the motors and lamps of the several oscillagraphs, would cause the motors to bring each photographic drum up to speed in about .1 second and also bring the lamps up to abnormal brilliancy and start the remote control apparatus so as to bring the transient on the film at the desired place.—J. W. Legg, *Electric Journal*, December, 1920.

THE KAPLAN HYDRAULIC TURBINE

The Kaplan high-speed water turbine, designed by Professor V. Kaplan of Brünn, Austria, is a development of the Francis type.

It is claimed that the inventor deserted the dogmatic theories adhered to in current practice, especially those resting on the conception of an "ideal fluid" which is never met with in practice, and disregarded all the rules based on the so-called theory of "water-filament flow." He, in his theory of turbine design, attaches as much importance to question of friction, which has been hitherto practically neglected, as has been done by others to the character of flow. According to his theory, other conditions being similar, it is the number of blades that has the determining importance. If it is too small, the flow of water suffers, and if it is too large, then the efficiency is reduced.

In an effort to create a turbine maximum speed, Professor Kaplan shortened as much as possible the length of the blades. Furthermore, he found that a large clearance does not harm in any way. This led him to locate the blades farther and farther back of each other until he obtained a runner having only actual flow. Finally, it is claimed that he succeeded by proper selection of the suction pipe in reconverting a large amount of the energy of the water at discharge into pressure. Contrary to what happens in a Francis turbine, the water flows throughout the runner in an axial direction, and the deflection of the water in the runner is eliminated. The guide apparatus is designed in the same manner as in the conventional Francis turbines, but the vanes are so arranged that the water discharges not only along the longitudinal edges, but also at the front edges. The guide wheel cover has been made flat.

The advantages claimed for the Kaplan turbine are as follows: (1) The turbine shaft can have its bearings located

nearer the center of gravity of the runner than is the case in the Francis turbine. This results in a stable, comparatively light construction, avoiding the difficulties due to unbalancing which are encountered in Francis high-speed turbines. (2) The runner is somewhat smaller in diameter than the draft tube at its narrowest place. This makes it possible to insert the runner into the casing both from the draft-tube side and from the guide wheel cover side, contrary to what is the case with high speed turbines, which can be installed only from the draft-tube side, which is not always easy to do. (3) The diameter of the runner boss can be kept comparatively small; likewise the free blade area is considerably smaller than in the Francis turbine. The weight of the Kaplan runner is therefore very much smaller, in fact, it is claimed to be on the average only about one-fifth of the weight of a Francis wheel of the same diameter. It has also a difficult method of holding the blades, as a result of which it is claimed that a Kaplan runner can be made in about one-fourth the time required to make a Francis runner. (4) The principal advantage of the new construction lies, however, in the fact that with a Kaplan turbine speeds become attainable which are beyond the capacity of the Francis turbine, in addition to which the efficiency of the turbine at various loads varies in a more advantageous manner than with the conventional turbines. These points are further elucidated.

It is important to have hydraulic turbines run at as high a speed as possible, because this permits a more economical utilization of the electrical generators usually connected to them; and it appears that the most economical speed of rotation for the generator is from 200 to 300 r.p.m. for power outputs of from 500 to 5,000 hp. and from 400 to 600 r.p.m for power outputs of from 100 to 500 hp. These speeds are beyond the range of Francis turbines unless the head of water is very large and the volume of water small. This results in uneconomical plants for low water heads, and as an illustration a calculation is given showing that in a low head plant with a turbine having an output at 5,000 hp. and running at 83 r.p.m., the generators at piece-time prices would cost about $37,000, while if the turbine could be run at 250 r.p.m. the cost of the generator would be only about $25,000. Furthermore, the high-speed turbine, all else being equal, would be built much cheaper than the low-speed machine. The low-speed machine is uneconomical from another point of view, namely, that where large volumes of water have to be handled, a large number of units have to be used since otherwise the velocity would have to be excessively low and the units excessively large. Numerous small units, however, are always more expensive than a few large ones.

The following unit speeds are given for the conventional types: 12 to 50 for Pelton wheels; 50 to 100 for Francis slow-speed wheels; 100 to 200 for Francis normal speed wheels; and 200 to 300 for Francis high-speed wheels. As compared with these, a very much higher figure is possible with the Kaplan turbine; the first of these turbines built in Sweden had unit speeds of from 500 to 600, the turbines tested at the Technical High School in Brünn, 900, and in recent tests speeds of 1,200 to 1,600 have been obtained with good efficiency.

Numerous brake tests show that the efficiency of the Kaplan turbine is not only very high but it is maintained high through wide variations of head and volume. It is claimed that this turbine will lead to an extensive utilization of medium and low pressure falls..—V. Kaplan, *Zeitschrift für das gesamte Turbinenwesen*, July 10 and 20, 1920. Also *Zeitschrift des Bayerischen Revisions—Verein*, May 15, 1920, pp. 71-73. Abstract of the latter—*Mechanical Engineering*, Sept., 1920, pp. 516-517.

ALUMINUM FOR TRANSMISSION LINES

M. DUSAUGEY describes in *Annales des Postes, Télégraphes et Téléphones* for September, 1920, the manufacture, qualities and use of aluminum for electric transmission lines. A Commission on Aluminum appointed in 1913 decided that the following rules should hold for commercial aluminum: (1) It should be 99 per cent pure. (2) For wires in suspension the breaking stress should exceed 20 kg./mm.^{2} for wires up to 35/10 and should exceed 18 kg./mm.^{2} for wires 35/10 to 50/10. The tolerance on strand diameter is 2 per cent, the tolerance on stress is 2.5 per cent. For aluminum used in machines and insulated cables the breaking stress should not exceed 9 kg./mm.^{2} (3) The limit of elasticity for hard-drawn wire shall not be less than 11 kg./mm.^{2} The extension at rupture of hard-drawn wire shall be 2 per cent, and of annealed wire 25 per cent. (4) The pliability shall be tested by bending through 180 deg. backward and forward round diameters as follows: For 1.0 mm. wire, 25 bends; 1.5 mm. wire, 20 bends; 2.0 mm. wire, 15 bends; etc. ()5 The resistance of annealed conductors shall be 2.89 microhms per cm.^{2} at 20° C., *i.e.*, 60 per cent copper conductivity. Conductivity of hard-drawn wire shall be 2.95 michroms. The temperature coefficient is taken as 0.00449 per 1° C. Tolerance on resistance, 1 per cent.

A comparison of aluminum with copper shows that the relative weight of aluminum to copper is 30 to 100 for equal section, 42 to 100 for equal heating by the same current, 50 to 100 for section of equal conductivity. At pre-war prices the saving in using aluminum becomes in these cases 55 per cent, 37 per cent and 25 per cent, respectively.

The increase of resistance due to high frequency currents is less in aluminum than in copper. Instead of using bronze, duralumin might be used. The author knows of only one aluminum-steel transmission line in Europe, namely, in the Dauphine, where a 60,000-volt transmission line at an altitude of 6,000 ft., made of 6 conductors, 3 being 112 mm.^{2} section and the other 3 of 88 mm.^{2} section, has lasted for two years with only two breakdowns; one due to the slipping of a support, the other due to an electrical contact with a low-tension wire. The use of aluminum steel lines with spans of 300 meters is suggested and a table of comparisons for such lines is given.—*Technical Review*, Jan. 4, 1921.

ELECTRO-SHERARDIZING

SHERARDIZING is one of the three processes for applying metallic zinc to iron and steel, the other two processes being hot galvanizing and zinc plating, both of which require the article to be carefully cleaned from dust and grease. Sherardizing, however, does not require such care, as the rust is penetrated by the zinc and the grease vaporizes. The work is usually cleaned by a sand-blast or a 16 per cent sulphuric acid pickling bath.

The work to be sherardized is packed into a drum with a small quantity of zinc dust, and the temperature raised sufficiently to vaporize the zinc, and in that state it penetrates beneath the surface of the metal. Sherardized articles can be bent and swaged without cracking or flaking off, and should be able to stand at least 100 hours of salt solution spray (specific gravity, 1.03) at 60° F. without sign of corrosion. There is a definite relationship between the temperature of the operation and the thickness of the zinc coating. It is therefore easy to obtain a suitable thickness, which is 0.002-0.0025 in. thick.

Where heat is supplied by electric power, there is a marked advantage in regard to accurate regulation of the temperature, cleanliness and convenience of operation. The most popular form of drum is one 24 by 24 by 40 in., operated at a temperature of 340° C. or 644° F. The current consumption is 53.5 kilowatts to bring the drum up to the required temperature, and 13.5 kilowatts to maintain it at 340° C. It usually takes about four hours to raise the temperature, and about three and a half hours to cool to 230° C., when the work may be taken out safely. There must not be a greater fluctuation than ±5° F. during the process.

The windings are contained in all four sides of the drum, and outside them is a packing of heat-insulating material. The current is supplied to three slip rings from carbon brushes.

Work which has been heat-treated cannot as yet be sherard-

ized, but the difficulty will doubtless be overcome in time.—*Machinery* (London), V. 16, p. 97, 1920. Through the *Journal of the Institute of Metals*, 1920.

CENTRAL STATION DEVELOPMENTS IN 1920

The central station output last year was 46,700,000,000 kw-hr., as nearly as can be estimated by the *Electrical World*. These figures represent an increased output over 1919 of 21.2 per cent and an increase in the revenue from the sale of energy of 19.2 per cent. Since 1914 the output has increased 178 per cent and the revenue has grown from $336,980,000 to $922,300,000, an increase of 174 per cent. Financial problems in this field overshadow all others. The needs for new capital are exceedingly great and the acquisition of it is difficult. Permits for water-power development alone, if they are granted, will tax the ingenuity and skill of manufacturers, executives and operators alike, for they involve 12,000,000 hp. and the expenditures of approximately $2,000,000 over and above the normal outlay for improvements and beteerment to existing generating and distributing systems. During 1920 about $400,000,000 of new money was raised by electric public utility companies for refunding and other purposes incident to the well-being and expansion of the business.

The growth of the industrial load has been phenomenal. A nation-wide survey indicates that 1,161,400 industrial motors were served by central stations in 1919 and the motor connected load is estimated at 12,930,000 hp. Energy sold to power customers has increased from 7,486,300,000 kw-hr. in 1914 to 22,046,400,000 kw. in 1919, or 57.2 per cent of the total output. In 1915 the energy sold to power customers was about 51.1 per cent of the total output, hence, the proportion of the total output has increased since by about 6.1 per cent.

Based upon a population of 110,000,000, central stations reach about 63,000,000, or 57 per cent of the population. Figuring 52 persons per dwelling there are about 13,000,000 dwellings in the territory covered by the central station lines of which 7,000,000 are wired. In all the states there are 21,000,000 dwellings. This leaves 6,000,000 dwellings adjacent to central station lines not now electrically wired, and 8,000,000 more to which service must ultimately be extended.

Survey of Progress in Mechanical Engineering

Prepared Under the Auspices of the American Society of Mechanical Engineers

PROBLEMS AND PROBABLE FIELD OF THE OIL ENGINE

By Paul Rieppel

The author starts with the discussion of the economical and political problems connected with the control of the world's supplies of oil and of the application of the oil engine by which he means the various types of internal-combustion engines, the Diesel and its modifications being considered in the first place.

In the course of his article the author makes many interesting observations and raises several questions well worth attention.

COMBUSTION PROCESSES

As regards the nature of combustion processes in the Diesel engine our knowledge has reached the point where we can clearly distinguish the processes of injection, vaporization, gas formation and combustion. The author believes, however, the very wide field in this domain remains as yet unexplored and that more work should be done in the laboratory by the physicist, such work being preferable in many cases to extensive experimentation on actual engines.

The most rapid and complete combustion is a function of the fineness of atomization, intermixture with air, and, to an extent which has not yet been fully appreciated, of turbulence. No thorough tests have been made to determine what is the best method to obtain the most complete atomization and what fineness of atomization is needed under each set of conditions.

What is the influence of catalysis in the cylinder, whether that due to presence of water or of some other catalytically acting material? The tests of Stein contain valuable material, but the influence of very small, in fact extremely small, amounts of water on fuel combustion remains as yet to be investigated. As a matter of fact, we know that under certain conditions very poor oils burn better in the presence of water and the use of other catalytic agents, such as silicon and various metals may bring startling developments in engine design and offer a means of increasing our available ability to control combustion.

How may we obtain the best possible conditions of turbulence and how to evaluate the influence of turbulence are questions which may be answered by tests on self-ignition of oils and the velocity of flame propagation therein. In a bomb oil vapor at rest does not ignite at all at temperatures corresponding to the temperature of compression in a Diesel engine, but when a slight turbulence is produced, as, for example, by blowing in some air, self-ignition takes place. Comparatively little has been done in this direction. This and other questions must be considered by everyone interested in the subject of combustion processes, and they are not mere academic problems but important stones in the foundation of which the structure of economic design of an engine has to be raised. Had we had this information a highly economic Diesel engine could have been designed long ago and have done away with the compressor.

From this the author proceeds to the discussion of various attempts to build a Diesel engine without a compressor, such as have been proposed by Vickers, Price and Steinbecker engines.

ECONOMY OF OPERATION

In the determination of the economy of operation the questions as to the use of a 4-stroke and 2-stroke cycle, high or medium pressure, are questions which lie at the foundation of the problem. After discussing briefly the relative position of the 4- and 2-stroke cycles and the question of scavenging, the author proceeds to the question of compression and asks whether we shall continue to operate Diesel engines with a compression of 35 atoms. and the heavy weight of the engine and mechanical difficulties which it involves.

The higher thermal efficiency secured with this compression does not have decisive value in the author's eyes, as motors employing lower compression pressures would have a lower first cost, be more reliable and show a better mechanical efficiency. As regards the advantage secured through self-ignition of the mixture, it is pointed out that the point of self-ignition goes down very materially when the cooling produced by the expanding stream of the air of injection is eliminated. With solid injection every condition of engine operation can be met without external means of ignition at a pressure of 25 atmos., but even assuming that self-ignition would have to be dispensed with: Why not? The high value placed on the ability of the engine to operate on a basis of self-ignition is a survival of a time when electrical ignition was still complicated and unreliable. Today it is quite easy to provide reliable means of producing a good electric spark having a good control of

timing, or, where necessary, to produce a wire spirally maintained at the blowing heat all the time by a flow of electric current. There is no reason why one should not employ outside methods of ignition in engines in which the most economical operation may be secured at compressions at which self-ignition can no longer be relied upon.

In connection with the problem of securing the most economical operation of oil engines, the author takes up the question of utilization of waste heat. It is true that as high as 40 per cent of the heat in the fuel may be usefully employed in the oil engine but this is no reason why one should waste the other 60 per cent without any effort at recovery. The comparison with the 12 per cent heat efficiency of the steam engine is often misleading because in a steam engine a good deal of the heat in the exhaust steam may be still utilized for purposes of heating and drying. In properly conducted factory processes employing steam, the power generated by the steam engine should be considered as a mere by-product, while in the case of oil-engine drive it is the main if not the only product of fuel combustion.

The problem of utilizing the waste heat of oil engines is one of the most important from an economical point of view. The usual way is to pass the exhaust gases on to steam boilers, a method well known in large gas engine operation. This cannot be employed as conveniently with oil engines, because the temperature of exhaust gases is considerably lower. Furthermore, any attempt at a thorough utilization of exhaust heat in oil engines would involve a considerable increase in the first cost of the installation and also possibly corrosion troubles due to the presence of sulphurous acid in the exhaust gases. In particular, in the case of auxiliary boilers on shipboard, it has been found advisable to equip them with direct oil heating in addition to heating by exhaust gases. An important physical problem is the determination of the coefficient of heat transfer from exhaust gases to the boiler wall. There is a question proposed by Nulfelt, but, in general, the coefficients now employed are more or less of a rough case and do not take into consideration many important factors.

In this connection attempts may be mentioned to mix the exhaust gases with steam and to add to them compressed air and utilize the mixture either in turbines or in reciprocating engines. It does not appear that any such efforts may lead to useful conclusions.

In another part of the same article, which will be abstracted at an early date, the author discusses the application of oil engines, in particular those operating on heavy oils as opposed to gasoline and kerosene engines to various specific purposes, such as driving of locomotives, road vehicles, tractors and aircraft.—*Zeitschrift des Vereines Deutscher Ingenieure*, Vol. 64, Nos. 49 and 50, Dec. 4 and 11, 1920, pp. 1021-1027 and 1051-1055.

WORK SPEEDS IN CYLINDRICAL GRINDING

By ROBERT J. SPENCE

THE author claims that the importance of the function of the speed-changing device in grinding machines does not seem to be understood in general by the operators, of whom a very large number believes that the faster the work revolves the greater the amount of work produced. The author believes this is erroneous and that to operate a grinding machine continually on the fastest work speed is just as wrong and just as wasteful as it would be for a lathe operator to run his machine continuously at a filing speed when turning work.

To prove this, the author analyzes a case where a man is grinding a bar of steel and using the fastest work speed and fastest table traverse with which the machine is equipped. He shows that when an excessively high speed is used only part of the wheel face is presented to the work, and when such a thing happens the remaining part simply laps over on the surface ground during the proceeding revolution of the work and there is a non-uniform wearing action. The portion of the wheel face which is not cutting but simply dragging on the work becomes glazed and adds useless friction to the operation, thus increasing the power consumption of the machine.

The importance of using the greatest possible radial depth of cut is discussed next. Even a small increase in the radial depth of cut permits for the same amount of work to reduce the number of table traverses which, for the same rate of traverse, means a material reduction in the time consumed in grinding a piece.

The question of the effect on the amount of stock removed in its relation to wheel wear when the speed of grinding is reduced, is also discussed in some detail on the basis of the graphic analysis of the action of a grinding wheel proposed by Prof. George I. Alden. A discussion of the numerical case indicates that in that instance a change of work speed from an excessive rate of 190 r.p.m. to a more rational speed of 75 r.p.m. increases the amount of stock removed per unit of wheel wear 150 per cent.—*Machinery*, Vol. 27, No. 5, Jan., 1920, pp. 438-440.

WATER PURIFIER IN VERTICAL BOILER

IN locomotive cranes the item of washing and maintenance work on the boiler is of great importance, especially on contract work where such water has to be used as is available.

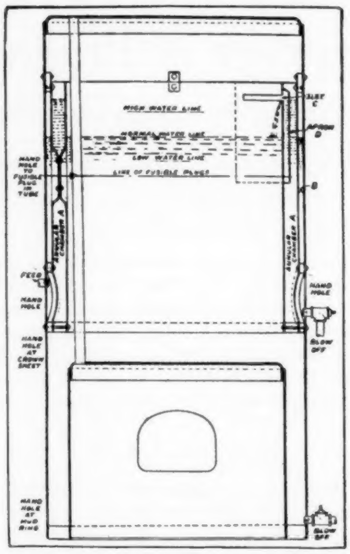


FIG. 1. PARKER LOCOMOTIVE CRANE VERTICAL BOILER WITH WATER PURIFIER

The locomotive crane boiler has been placed on the market equipped with an annular scale chamber located between the tubes and the shell plate, Fig. 1.

The feedwater is passed through this scale chamber at about 1/200 of the speed through the intake pipe and attains a temperature at which the scale-forming impurities are liberated from solution without the use of any chemicals. The impurities are then carried in suspension and as the movement of the water is very slow these suspended precipitates settled down readily to the bottom of the chamber. This settling is accelerated by the decrease in density of the water as it is heated and by the decrease in its fluid friction.

The purifier consists of the annular scale chamber A extending completely around the tubes with a 1-in. water space B between this chamber and the boiler shell. The outlet into the main portion of the boiler is the slot C guarded by the apron D. The feedwater is admitted directly to the scale chamber A at a point farthest from the outlet slot. It travels slowly around this chamber to the outlet and reaches approximately the boiler temperature before overflowing. The apron D keeps any floating impurities, such as grease, oil, etc., from being discharged into the main boiler.

As regards the efficiency of this purifying device, it is stated that in one test of a 42-in. diameter boiler of this type, at Pat-

erson, N. J., a feedwater naturally carrying 5 grains per gal. was loaded with 70 grains of calcium and 70 grains of earth, a total of 145 grains per gal. The feed was taken from a barrel agitated with carbonic acid gas to form calcium carbonate. After about 1,200 gal. of this kind of water had been passed through the boiler, it was allowed to cool and the heating surface and lower mud ring were found to be perfectly clean and the mud was about 6 in. deep in the scale chamber. The blowoffs were both plugged so that all impurities remained in the boiler.—*The Iron Trade Review*, Vol. 68, No. 4, Jan. 27, 1921, p. 293.

SAND BLASTING

By C. W. Starker

A practical article describing the types of apparatus abrasives, nozzles, air pressures, dust exhausting and general methods of operating.

There are several systems of sand blasting differing in the manner of applying the stream of abrasive to the surface to be treated. Air compressed to varying pressures is commonly employed in all sand-blasting equipment, but the pressure is applied in different ways.

In the direct pressure system the air and the abrasive are combined in and discharged from a closed tank through a nozzle. In the suction system the abrasive is carried to the nozzle by the suction created by a jet of compressed air, which, in passing through the nozzle carries the abrasive with it. This system is also known as the siphon system. For this system the apparatus used like the sand-blast gun is employed. In the third system, known as the gravity system, the abrasive is carried by mechanical means to a place above the nozzle and is fed down by gravity.

In general it may be said, other things being equal, that the higher the air pressure used the stronger the forces of the jet discharged against the surface to be treated, and therefore the greater the amount of work done. It may be roughly stated that according to actual practice 50 lb. air pressure will perform twice as much work as 20 lb., or 65 lb. will accomplish twice as much as 30 lb., and 72 lb. twice as much as 40 lb. The air pressure used for different materials are as follows (fair average practice): Steel castings or forgings, 80 to 100 lb.; malleable iron, 70 to 85 lb.; and iron, 60 to 70 lb.; and brass and aluminum, 35 to 50 lb.

The volume of air flowing to a nozzle opening at a given pressure is governed by the size of the nozzle. (Table 1). As the nozzle is apt to wear, however, it is important to design it so as to reduce this wear as much as possible. Moisture in compressed air prevents an even flow of abrasive and causes the sand to form lumps. It is also deterimental to pneumatic tools which are operated from the compressed air system.

As regards the abrasive materials, sand is the most commonly used on account of its relatively low price. Ordinary lake or river sand is inferior to sea sand and silica sand. Abrasive, such as steal grit and shot, are used to a certain extent, but are not suitable for work such as electroplating or galvanizing, as the adherence of metallic dust prevents the success of the final process. All abrasives should be screened each time before using to remove particles large enough to plug the nozzle and also to eliminate fine particles which only produce dust and have no abrasive quality.

It is important to have the sand blast rooms well ventilated. In the majority of cases it is also necessary to provide methods for gathering and settling the dust rather than discharging it into the atmosphere.—*Machinery*, Vol. 27, No. 5, Jan., 1921, pp. 458-462.

Table 1. *Flow of Free Air for Different Sizes of Nozzles*

Diameter of Nozzle, Inches	Pressure (Cubic Feet per Minute) and Corresponding Horsepower Required															
	20 Pounds	HP.	30 Pounds	HP.	40 Pounds	HP.	50 Pounds	HP.	60 Pounds	HP.	70 Pounds	HP.	80 Pounds	HP.	100 Pounds	HP.
1/8	7.70	0.63	10.00	1.03	12.30	1.50	14.50	1.99	16.80	2.57	19.00	3.19	21.20	3.86	25.73	5.33
3/16	17.10	1.40	22.50	2.32	27.50	3.26	32.80	4.40	37.50	5.74	43.00	7.22	47.50	8.65	57.88	11.98
1/4	30.80	2.53	40.00	4.12	49.10	5.99	58.20	7.99	67.00	10.25	76.00	12.77	85.00	15.47	103.00	21.32
5/16	48.17	3.95	62.89	6.48	76.60	9.36	90.70	12.43	105.00	16.07	119.00	20.00	133.00	24.10	161.00	33.82
3/8	69.00	5.66	90.00	9.27	110.00	13.42	130.00	17.81	151.00	23.10	171.00	28.73	191.00	34.76	232.00	47.90

Progress in Mining and Metallurgy

Abstracts of Papers and Recent Articles

Prepared Under the Auspices of the American Institute of Mining and Metallurgical Engineers

THE ELECTRIC FURNACE IN THE IRON FOUNDRY

By Richard Moldenke

One of the gravest problems of the iron foundry today is the accumulation of sulphur in commercial scrap and its effect on the castings made therewith.

In the ordinary cupola remelting of pig and scrap, at least 0.02 per cent sulphur is taken up; often double that amount.

Until the advent of the basic-hearth electric furnace, the only method of holding the sulphur within reasonable limits was to use high percentages of pig in the foundry mixtures. Pig iron seldom contains over 0.05 per cent sulphur, if well made.

Before the iron foundryman, particularly the producer of gray and malleable iron castings, can pour his molds safely, the molten metal must have a high degree of superheat, be thoroughly deoxidized, and reasonably low in sulphur. A foundryman will get these characteristics if he uses good materials and melts properly. The electric furnace will give a highly superheated metal that is thoroughly deoxidized, and a fine degree of desulfurization if the hearth is basic.

The foundryman may melt cold metal directly in the acid or basic-hearth electric furnace, or he may refine molten cupola or furnace metal in either hearth or electric furnace. The problem of the electric furnace in the foundry resolves itself into either adding the necessary electric equipment for duplexing, or installing electric furnaces for direct melting and refining of cold stock. Of the two hearth systems the basic is to be preferred for its specific value in desulpherization.

Electric furnaces of large tonnage are expensive, a 3-ton outfit, which ordinarily would be considered quite large, costs about $35,000 at this writing. For a moderate degree of refining—that is superheating, deoxidation and desulfurization—the metal, as taken from the cupola, should remain in the electric furnace at least ½ hr. With rapid repairs after

tapping out, fully ¾ hr. will be required for each batch of molten metal. For an average foundry, melting say 20 tons daily in a 54 in. cupola, the heat will last 2 hr., which permits the treatment of only half of it by the duplex method. Unless the product of the establishment can be divided into high-grade and ordinary work, the duplex process will be difficult to install with the present daily routine. Foundries can do this in most cases, hence an electric-furnace equipment added to the ordinary foundry will work out very nicely.

The selection of the basic-hearth electric furnace involves several considerations. In the acid-hearth furnace, the slag situation is easier, deoxidation is readily accomplished by providing a slag cover with additional periodic charging of fine coke on this to hold the furnace atmosphere neutral. The intense heat of the bath, with its high carbon percentage, takes care of all oxygen that may be in the metal in some combination. The disadvantages of the acid-hearth furnace are that, whether melting cold metal or duplexing, it is necessary to start with comparatively good material, as the sulfur question remains. Further, there is a marked addition of silicon in the bath by reduction from the silica hearth and slag, if refining is carried on for any length of time. The advantages of the acid-hearth are the cheaper refractories required, the furnace body lasting as long as an open-hearth furnace and in much easier slagging conditions. Where, therefore, the question of extremely low costs is not so serious an item, there is no reason why an acid-hearth electric furnace should not be used for melting from cold metal, for the sulfur can be held down by using high percentages of good low-sulfur pig iron—the melting process gives no additional sulfur, as is the case in cupola melting.

In view, however, of the sulfur conditions in purchased scrap and the desirability of holding down the sulfur maximum, the basic-hearth electric furnace should be used in every new installation, whether for cold melting or duplexing.

COAL PILLAR DRAWING METHODS IN EUROPE

By George S. Rice

Some form of longwall mining is generally used in Continental Europe; also in Great Britain where the coal is weak and friable, or the coal bed provides material for pack walls and filling, or where the bottom is soft and squeezes up easily, or the roof is pliable, or the bed is thin and brushing provides building material, or the thick multiple seams are mined in layers, such as the 24-ft. seam at Weymiss, Scotland, or the 10-yd. pitching bed near Coventry, England. But pillar methods have been retained in British fields where the coal beds are from 5 to 9 ft. thick, and free from thick partings or binders or without draw slate, which would provide waste rock for pack walls, or where the roof is hard and requires shooting to bring down and the bottom or floor is comparatively hard.

The room-and-pillar system, by which probably 95 per cent of the coal of the United States is produced, is now found in only a few mines in Wales, where it is known as the pillar and (single) stall method. The American room-and-pillar system is not equivalent to the bord-and-pillar or stoop-and-room system.

The bulk of the coal mined in Europe comes from a depth of more than 1,200 feet., while the deepest mines in Great Britain, Belgium, and France reach 3,500 to 4,000 feet.

It is generally conceded, without reference to the cost of production, that the larger the pillars left on the first mining, the more thoroughly can the coal be extracted. In Europe complete extraction is generally compelled either by the lessors or by the governments; whereas in this country, it has been more largely a question of competitive cost of production, or the support of the surface in the flat farming districts of the Middle West, that has determined how completely the coal is to be extracted.

Systems employing pillars, used in Europe, may be classified as follows: Pillar and (single) stall; pillar and double stall; square chamber method of South Staffordshire; bord-and pillar, or, stoop and room; rooms or bords hydraulically sand-filled.

In Upper Silesia, room-and-pillar methods of ordinary type were used extensively in beds 10 to 60 feet thick; but owing to extensive fires and trouble from subsidence of surface and generally poor recovery of coal, these methods have been supplanted by longwall and hydraulic-sand filling methods.

SUMMARY

1. In Europe, only a small proportion of the coal production is obtained by mining systems employing pillars other than shaft pillars under buildings, or barrier pillars.
2. Pillar systems are employed to a limited extent in Great Britain and in connection with sand-filling in Upper Silesia.
3. The typical American room-and-pillar system is not employed in Europe except in a few places in Wales.
4. The principal pillar system, where it is used at all, is the bord-and-pillar, in which the pillars are extensive, compared with the area taken out by the preliminary bords and headways, in general not over 10 or 15 per cent of the coal is taken out in advancing.
5. In its best form, the bord-and pillar system permits a recovery of 95 per cent of the coal, by what is practically a retreating longwall method.
6. The pillars are extracted by successive splitting or slicing.
7. The bord-and-pillar system is applicable only where the coal and roof are relatively strong and the coal is free from large partings, and there is no draw slate which requires gobbing.
8. The American room-and-pillar system approaches the bord-and-pillar where the rooms are narrow and the pillars wide and the retreat is carried on a diagonal line, as in mines of the Connellsville district of Pennsylvania, and in some of the deep mines in the Rocky Mountain region.

SKIP HOISTING FOR COAL MINES

By Andrews Allen and John A. Garcia

The superiority of skip hoisting in metal mining is shown by its almost universal adoption.

By varying the size of skip and the rope speed, any desired hoisting tonnage can be secured and, since only one kind of material is handled and breakage is unimportant, the loading of the skips can be easily and cheaply effected from bins into which the cars are dumped. The cars may then be designed to fit the conditions in the mine instead of being a compromise between hoisting and mining conditions, very likely suiting neither.

In coal mines, the usual practice has been to hoist the car to the surface, either on platform or self-dumping cages. Of late years the number of skip-hoisting plants in coal mines has been rapidly increasing, but there is more or less inertia to overcome in establishing so radical a change in practice, also the earlier skip operations were not uniformly or completely successful. As a result it became evident that metal mining practice would require radical modification before skip hoisting could be successfully used in coal mining.

OBJECTIONS TO SKIP HOISTING—BREAKAGE

Except where coal is used for coking or other purposes where breakage is unimportant, the breakage of the coal is of vital importance all the way from the face to the railroad car.

The difficulty of inspection and docking, in the opinion of the writers, is one of the most serious objections to skip hoisting, yet it is easily overcome. In a large mine it is impossible to examine and dock each car separately. The effort of mine managements should be directed to securing clean coal at the face, and the only practicable method of checking the loaders is to employ a "spotting system," by means of which a certain number of cars, taken at random or from sections of the mine where careless loading is suspected, can be taken

out, carefully and thoroughly inspected, and the docks identified and charged against the guilty loader.

Where the coal is dumped indiscriminately into a deep pit, no docking or spotting system is possible, except through the use of an auxiliary shaft; but where a skip installation is properly designed, it is just as possible to dock with a skip as with a cage, and without any greater inconvenience or sacrifice of output.

It is possible, in a skip mine, to provide an excessive hoisting capacity, which will take care of the rock, as well as the coal; where the deep pit is not used, the design can be easily arranged so that a moderate quantity of rock can be handled at the main hoisting shaft without the slightest difficulty.

A skip will not handle men or material unless equipped with an auxiliary deck, in which case it becomes cumbersome and inconvenient.

The advantages of skip hoisting are:

A hoisting capacity, capable of taking care of all the coal and rock that can be mined.

A smaller shaft.

A large ratio of lading to gross weight.

STATIC AND DYNAMIC TENSILE TESTS ON NICKEL STEEL

By J. J. Thomas and J. H. Nead

This investigation was undertaken to determine, if possible, the relation between static and dynamic tensile tests as measured by the work required to break test specimens slowly, in a tensile testing machine, and rapidly, by means of a falling weight. It was hoped that the investigation would throw some light on the rôle played by ductility under different rates of application of load.

Results indicate that more work is required to break a specimen under a rapidly applied load than under one slowly applied.

Nickel steel that has been quenched but not drawn, or drawn up to 300° C. is very brittle, and required very little work to break it under either a rapidly or slowly applied load.

The ductility is independent of rate of application of load.

As work is the product of force and distance, we must conclude that as the elongation is the same and the work is greater, the resisting force of the metal is greater for suddenly applied loads.

For a slowly applied load this metal was hard and brittle when drawn at temperatures of 300° C. or lower. Beyond this point, however, a real softening effect is obtained. For low drawing temperatures, the maximum strength, yield point, and elastic limit, or limit of proportionality, occur at the same point, thus giving a brittle steel that fails without warning. This may be due to internal strains that have not been removed, or to the hard martensitic structure of the steel. For higher drawing temperatures there is a marked increase in the ductility and a greater resistance to shock.

CONCLUSIONS

For hard steels the total work of rupture is very low under either a slowly or a rapidly applied load.

The modulus increases slightly with the higher drawing temperatures; this increase is probably too slight, however, to have a commercial value.

If we could be absolutely sure that the applied stresses would never exceed the elastic limit, and that the steel would never be subjected to a live load, we could use a hard steel, and with a smaller area obtain the same resisting force of a soft steel, due to the higher elastic limit. In most problems of design, however, live loads will be encountered, either during the fabrication of the material or in service.

Hard steels require little work for rupture; therefore, any small suddenly applied load would be sufficient to cause fracture.

For the low drawing temperatures both the ductility and the work of rupture are very low. As ductility increases, the work of rupture increases. For hard steels, therefore, a small force, less than the elastic limit, if applied with sufficient velocity, will develop enough kinetic energy to cause rupture.

It is evident that force alone is not the proper criterion by which to measure the strength of material. The work unit is more valuable as a measure of strength, and as ductility is an indication of the work required to rupture, it is wise to specify a higher ductility for all parts subject to shock.

Ductility, as measured by elongation and reduction of area, in the ordinary tension test, is important, therefore, not for the part it itself plays but as an indication of strength as measured by work units. Steel is in its best condition when quenched and drawn just under its critical temperature.

ALASKAN COAL FIELDS

By George Watkin Evans

Many areas of coal-bearing rocks are widely distributed geographically from Cape Lisburne, on Bering Sea, to Admiralty Island south of Juneau. Bituminous coal is found at Cape Lisburne, on the Bering Sea, at Five Finger Rapids on the upper Yukon, and at Herendeen Bay and Chignik Bay; lignito is found on the Kobuck River, along the Yukon River from points near the mouth to Tonakat, near Rampart, at Dawson; on the east shore of Cook Inlet and in the Tanana Valley 50 miles south of Nenana.

The Susitna and Matanuska Valleys contain coal ranging from lignite to anthracite, and in the Bering Lake district there are coals ranging from semi-bituminous to anthracite.

TOTAL COAL AREAS IN THE ALASKAN COAL FIELDS

It is estimated, by Stephen Capps of the United States Geological Survey, who mapped the Nenana coal field, that 165 square miles of land are underlain with coal-bearing strata in that district.

Dr. George C. Martin, of the United State Geological Survey, estimates that there are 54 square miles of supposed coal-bearing formations in the Matanuska field proper and that probably an additional 24 square miles might be regarded as extensions of supposed coal-bearing areas. The area between Eska Creek and Moose Creek undoubtedly contains a large tonnage of minable coal, but the area between Chickaloon and Kings River is somewhat doubtful; at least the more recent work done in this part of the field indicates considerable doubt as to the continuity of the beds between these two places. Work is being done at the present time by the United States Navy to demonstrate the amount of minable coal in the area lying between Chickaloon and Kings River. An additional area of coal bearing strata lies eastward of Chickaloon and it is probable that, with further development, additional areas of high-grade coal will be found within this district.

The Kachemak Bay field contains a large total area of coal-bearing strata. The coal bearing formations appear to extend to the eastward from Bluff Point to the head of Kachemak Bay and to the northward along the northeast shore of Cook Inlet for a considerable distance.

The Bering River field contains approximately 22 square miles of coal-bearing formation in the bituminous portion of the field and perhaps 25 or 30 square miles of coal-bearing formation in the anthracite part of the field. Of the 20 square miles or more of coal-bearing strata in the bituminous area, only a comparatively small portion will prove to contain coal that can be mined at a reasonable cost, for which reason the total tonnage of minable coal within this portion of the field will be much less than is generally supposed. The same is true of the anthracite part of the field.

Exploitation of the Alaskan coal fields began about 1903 and development continued, in a small way, in the Bering River field until 1908, when President Roosevelt withdrew the Alaska coal lands from entry. Some development work had been done in the Matanuskan coal fields and a small amount of work had been carried on in the Kachemak Bay field. Since 1915,

it has been possible to lease coal land in both the Matanuska and the Bering River fields; the Kachemak Bay and the Nenana coal fields have more recently been subdivided into leasing units.

Three attempts were made by private lessees within the Matanuska field to develop commercial coal mines, but all three failed. The Government has taken over one of the leases to supply the needs in railroad construction.

Several attempts have been made in the Bering River field to develop profitable coal mines. It appears that one or two of the companies in this field will develop coal mines of small production which will probably pay to operate. Taking the investment in this field as a whole, the coal mining venture has been a loss. Instead of retarding private development in any of the Alaska coal fields, the Government should have encouraged legitimate development. The Government has assumed the latter attitude during the past few years.

Correspondence

The editor is not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.

A METHOD OF BALANCING CHEMICAL EQUATIONS

To the Editor of the SCIENTIFIC AMERICAN MONTHLY:

One of the exercises of the student of chemistry is the writing of chemical equations, which are succinct statements by means of numbers and symbols, expressing the chemical transformations in a given reaction, as also the quantitative relations of the substances involved in the change. The interacting substances, written on the left-hand side of the equation, are called the factors, the resulting new substances, written on the right-hand side, are called the products. It has long been known that the weight of the factors equals that of the products, that is to say, in chemical changes, matter is neither created nor lost, but only transformed.

These well established facts justify that process which the student resorts to, called the balancing of chemical equations. After having ascertained, either by his own experimentation, or someone's else all the factors and products, he writes the preliminary equation, making sure that the formula of each substance is correct, though without the numerical coefficients before the formulas.

His next step is to balance the equation, that is, so choose the coefficients, that the number of atoms of each element on either side of the equation shall be equal. Every teacher and student of chemistry has no doubt experienced some difficulty at times, and very often has consumed much valuable time in this last operation. This, of course, is not the case, when the reactions are simple, since mere inspection will at once suggest the proper coefficients to be placed before each of the factors and products. In proportion, however, as the reaction becomes more complex, inspection becomes more difficult, and the method of trial coefficients must be invoked, which involves a certain amount of guess-work, with the consequent uncertainty and loss of time.

When such difficult equations arise, we may use the method, described below, which very often will take the guess out of the problem of balancing chemical equations. The method is based on the principle that a chemical equation conforms in some respects to the algebraic equation, and hence the algebraic process may be legitimately used. This does not mean that all algebraic processes may be used, because the two kinds of equations do not conform in all respects.

Let us take as an example the following reaction, in which the required coefficients are indicated by letters:

$$aCrCl_3 + bNaC_2H_3O_2 + cH_2O + dCl = eNaCl + fH.C_2H_3O_2 + gNa_2CrO_4.$$

As the number of atoms of each element on the left-hand side must equal the number of the same element on the right, it follows that we may write the following equations:

For Cr: $a=g$ (1) For C: $2b=2f$ (4)
For Cl: $3a+d=e$ (2) For H: $3b+2c=4f$ (5)
For Na: $b=e+2g$ (3) For O: $2b+c=2f+4g$ (6)

Assume a value 1 for a, and we have: $a = 1$; whence also $g = 1$.

From (4): $b=f$.
Then (6) becomes: $2b+c=2b+4$. Whence $c=4$.
Then (5) becomes: $3b+8=4b$. Whence $b=8$.
Therefore also: $f=8$.
Then (3) becomes: $8=e+2$. Whence $e=6$.
Then (2) becomes: $3+d=6$. Whence $d=3$.

Substituting these values in the original equation, we have:

$$CrCl_3 + 8NaC_2H_3O_2 + 4H_2O + 3Cl = 6NaCl + 8H.C_2H_3O_2 + Na_2CrO_4$$

Since it is more accurate to write $3Cl_2$ than 3Cl, the equation may be so corrected by multiplying each coefficient by 2.

It sometimes happens that the solution of the simultaneous equations involve fractional values. In such cases the fractions may be got rid of by multiplying each number by a suitable integer. For example, in the following reaction:

$$aCu + bHNO_3 = cCu\ (NO_3)_2 + dH_2O + eNO.$$

After solving as above we have:

$a=1$; $b=8/3$; $c=1$; $d=4/3$; $e=2/3$.

Multiplying by 3 we have: $a=3$; $b=8$; $c=3$; $d=4$; $e=2$.

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APPEARANCE OF THE FUR HAIRS OF VARIOUS MAMMALS

IN last month's issue of SCIENTIFIC AMERICAN MONTHLY on page 131 there appeared an engraving showing the microscopic appearance of fur hairs of various mammals. In each figure two hairs were shown; one treated to show the cuticular scales, and the other to show the medulla. While the engraving served to show variations of different fur hairs the animals from which they were taken were not designated, and as this information will undoubtedly be of value to our readers we give here a list of the animals, prepared by Dr. Leon August Hausman. The numbers following each name are the diameters of the hairs in micra:

Fig. 6. Ermine (*Putorius erminea*)—17
Fig. 7. Mink (*Putorius vison*)—11
Fig. 8. European Otter (*Lutra vulgaris*)—10
Fig. 9. Wolverene (*Gulo luscus*)—25
Fig. 10. Fitch (*Mustela putorius*)—18
Fig. 11. Koala (*Phascolarctos cinereus*)—22
Fig. 12. Duckbill, or Platypus (*Ornithorhynchus anatinus*)—8
Fig. 13. Rabbit (*Lepus nutalli mallurus*)—17
Fig. 14. American Gray Squirrel (*Sciurus carolinensis*—(18
Fig. 15. Chinchilla (*Chinchilla lanigera*)—16
Fig. 16. Woodchuck, or Marmot (*Arctomys monax*)—22
Fig. 17. Muskrat (*Fiber zibethecus*)—17
Fig. 18. European Mole (*Talpa europaea*)—17
Fig. 19. American Mole (*Stalops aquaticus*)—17
Fig. 20. Raccoon (*Procyon lotor*)—20
Fig. 21. Opossum (*Didelphys virginiana*)—37
Fig. 22. Nutria, or Coypu rat (*Myocastor coypus*)—11
Fig. 23. Red Fox (*Vulpes pennsylvanicus*)—19
Fig. 24. Black Bear (*Ursinus americanus*)—27
Fig. 25. Canada Lynx (*Lynx canadensis*)—19
Fig. 26. Civet (*Arctogalidia fusca*)—21
Fig. 27. Skunk, or Marten (*Mephitis mephitica*)—26
Fig. 28. Hair Seal (*Otaria jubata*)—105 (protective hair)
Fig. 29. Badger (*Taxidea americana*)—57